

PRODUCTION TECHNOLOGY OF ORNAMENTAL CROPS, MAP & LANDSCAPING



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COURSE OUTLINE

- 1. Importance and scope of ornamental crops, medicinal and aromatic plants and landscaping.**
- 2. Principles of landscaping.**
- 3. Landscape uses of trees, shrubs and climbers.**
- 4. Production technology of important cut flowers like**
 - i. rose,
 - ii. gerbera,
 - iii. carnation,
 - iv. lily
 - v. orchids under protected conditions
- 5. Production technology of important flowers under open conditions like**
 - i. gladiolus,
 - ii. tuberose,
 - iii. Marigold'
 - iv. Jasmine
 - v. chrysanthemum under open conditions
- 6. Production technology of important medicinal plants like**
 - i. ashwagandha,
 - ii. asparagus,
 - iii. aloe,
 - iv. costus,
 - v. Cinnamomum,
 - vi. periwinkle,
 - vii. isabgol
- 7. Production technology of important aromatic plants like**
 - i. mint,
 - ii. lemongrass,
 - iii. citronella,
 - iv. palmarosa,
 - v. ocimum,
 - vi. rose,
 - vii. geranium,
 - viii. vetiver.
- 8. Processing and value addition in ornamental crops and MAPs produce.**

CHAPTER1**Importance and Scope of Floriculture and Landscaping**

Floriculture is a branch of horticulture concerned with the production, utilization and marketing of flowers and ornamental plants along with the beautification of surrounding i.e. landscaping. Floriculture crops include bedding and flowering plants, foliage plants, edges and hedges, climbers, cactus and succulents, cut greens and cut flowers. Flowers may be grouped as cut flower or loose flower. The flower with a substantial stem is known as cut flower whereas stemless flowers are loose flowers. The floriculture sector is experiencing rapid changes due to globalization and its effect on income regeneration in different parts of the world is resulting in rising per capita consumption of flowers in most countries. Besides, the traditional centers of production (U.S.A., Japan, Italy, The Netherlands and Columbia), new production centers are developing in Latin America, Africa and Asia with the quick increase in production. The Asian countries like India, China, Vietnam and many others are moving in the direction of more intensive floriculture.

Importance

It is a fast emerging commercial agri-business which due to diverse importance is an integral part of religious, social and cultural ceremonies. Beside decoration, it is a symbol of our Indian culture, tradition and heritage. The traditional flower business comprises of cultivation of almost loose flowers and in fact it is the backbone of the marginal and small farmers of India. The sale of loose flowers like jasmine, crossandra, marigold, china aster, chrysanthemums, barlaria and gaillardia are a roaring business in south India. Modern-day floriculture refers to the production of high-value cut flowers such as rose, gladiolus, carnation, mums, orchids, tuberose, anthurium, lily, gerbera, alstroemeria and bird of paradise. Nowaday, growing of these cut flower crops, suited for flower arrangements/decorations for bouquets preparation, gift and for floral baskets, have increased substantially and its share of the total trade has also improved. In terms of monetary gain flowers are the highly economic crops which has a wide potential in foreign market if produced qualitatively. It provides more return/unit area than any other agricultural/horticultural crops. These are short duration crop whose yield is also higher in per unit area. This sector generates employment as professors, landscape architect, nursery manager, entrepreneurship, agri-business manager, grower, supplier and consultant. It has more productivity and bears 25-30% more foreign exchange earning capacity than cereal crops.

Floriculture has emerged as an important sector for diversification of agriculture. Floriculture generates self-employment opportunities round the year. It has chances of employment especially for women. Beside its beauty in fresh form, it yields essential oils, pigments, extracts, value added products, flavouring agents and durable gift items. There is lot of demand for good quality flower seeds and ornamental planting materials. Aromatherapy is the new dimension of horticultural sciences to heal the psychic disability. Floriculture as a therapeutic tool is now being utilized in psychiatric hospitals and physical rehabilitation centers against depression and other psychological ailments. Government of India has identified the floriculture sector as the most extreme focus area for export. It is now treated like cash crops which beside above uses can be successfully utilized in pharmaceutical and perfumery companies. Floricultural crops have more chances of export in foreign markets. It has annual growth potential of 25-30%. It maintains the ecological balance and checks environmental pollution. Flowers symbolize the purity, beauty, peace, love, adoration, innocence and passion. Hence, many flowers are used to express the most sensitive, delicate and loving feelings eloquently what our words fail to express.

Scope/Strength of Indian Floricultural Industry

Central geographic location to the major flower consumption centers Diverse agro-climatic conditions.

Rich gene pool.

Natural habitat for many ornamental species.

Superiority of many of the species in terms of desirable horticultural traits. Low labour cost in comparison to the European countries.

Fast growing domestic market and export demand.

Recent liberal Government policies in the floriculture sector.

Subsidy on airfreight for export of cut flowers and tissue-cultured plants.

Deduction in import duties on cut flowers, flower seeds and tissue-cultured plants. Setting up of walk in type cold storage at the International airports.

Direct subsidy up to 50 percent of the precooling and cold storage units is available, as well as subsidy for using improved packaging material is given by APEDA.

Refinance assistance is available from NABARD to a number of hi-tech units at reasonable interest rate.

Among other things, flower Auction Centres are also coming up in Bangalore, Mumbai, Noida, near Delhi, and Kolkata. These are ready made market facilities for

trading and price discovery for a variety of flowers, both for export and domestic markets

“Six Agri Export Zones have been set up in the states of Sikkim, Tamil Nadu, Uttaranchal, Karanataka and Maharashtra. APEDA has also taken number of measures to facilitate floriculture exports.

Floriculture has a significant role to play in the development of Indian agriculture. Indian entry in export oriented floriculture is appreciable. The potentiality is abundant. Though the entry is late, yet it provides a lot of opportunities. For the growth of this nascent industry there is a need to exploit all resources – internal and external. The prerequisite for the success of floriculture is low-cost investment, self-developed technologies at minimum cost and good management with study of the market. Availability of natural resources, diverse agro-climatic conditions and fertility of the soil has created wide potentialities for floriculture in India. But despite the favourable natural conditions, the country has not been able to achieve significant growth in floriculture. It has not been able to find its place in the world trade of floriculture due to various reasons. Lack of adequate and appropriate technology for export-oriented floriculture units is an important factor that needs to be addressed. Over the changing period, changing life- styles and world becoming shorter on account of faster communications and transport, floriculture has assumed a definite commercial status in recent times. Hence, commercial floriculture is blossoming as a viable agribusiness alternative.

Floriculture in India is being viewed as a rapid growing industry. Commercial floriculture is becoming important from the export angle. The liberalization of industrial and trade policies paved the way for development of export-oriented production of cut flowers. The new seed policy had already made it feasible to import planting material of international varieties. The government of India offers tax benefits to new export oriented floriculture companies in the form of income-tax holidays and exemption from certain import duties. Agricultural and Processed Food Products Export Development Authority (APEDA) is responsible for export promotion and development of floriculture in India, grants subsidies for establishing cold storage, precooling units, refrigerated vans and green houses and air freight subsidy to exports. It has been found that commercial floriculture has higher potential per unit area than most of the field crops and is therefore a lucrative business.

Landscaping which was only an art and science in the earlier days has now emerged as a huge industry. With the importance and need of landscaping in beautifying and

conserving the environment being strongly felt now, the concept of landscaping and gardening is growing rapidly. Gardens have become essential to modern civilization. The gardens serve the purpose of public recreation and education. They serve to refresh the body and the mind. Home gardening is an integral part of family life and it lends itself for the family to relax and enjoy the nature and beauty of garden. This fieldof landscaping is slowly gaining momentum in our country especially in big cities. The government has also established many parks and a few Botanic gardens in ourcountry.

Importance and scope of Medicinal and aromatic plants

Aromatic plants: Aromatic plants are those plants which contain essential oils in them. This essential oil is the odiferous steam, volatile constituent of the aromatic plant.

Oils are usually present in the aerial part of plants such as flowers, fruits and leaves. Occasionally, they also accumulate in roots and woods eg. Vetiver and Sandal wood, respectively

Most of the commercial essential oil bearing plants belongs to the families Labiateae, Myrtaceae, Rutaceae, Compositae, Rosaceae, Umbelliferae, Poaceae and Pinaceae
Importantaromaticplants-Lemongrass,Palmarosagrass,Vetiver,Geranium, Mints, Ocimum, Patchouli, Lavender, Sandal Wood, Rose, Davana etc.

Importance of Aromatic Plants

1. In food and flavour industry to improve the flavour of thefood.
2. In perfumery, soap, agarbatti andcosmetics.
3. Pharmaceutical and drugindustries.
4. To manufacturepesticides,disinfectantsduetoantifungal,antiseptic and insecticidalproperties.
5. In paint industry – assolvents.
6. Distilledwastesareusedinmanufactureofcardboards,cheappaper, and packingmaterial.
7. SomeoftheimportantaromaticplantslikeLemongrass,Citronella,Palmarosagrass, Vetiver, Geranium, Lavender, Dawana etc. have great demand in ourcountry.

Area and Production of Medicinal and Aromatic Plants

(During 2016-17) according to NHB,

2017: Area- 634.00 (in '000 ha)

Production- 1030.85 (in '000 MT)

Important Organizations

NAMPB- National Aromatic and Medicinal Plant Board is situated at New Delhi

CIMAP- Central Institute for Medicinal and Aromatic Plants is located at Lucknow

**NRC for MAP- National research centre for Medicinal and Aromatic
Plants is located at Anand, Gujarat**

CHAPTER2**Principles of Landscaping**

Landscape design is the arrangement of outdoor space in a way that serves the needs and desires of people without damage to natural ecological relationships. The creation of usable, imaginative landscapes depends upon how skillfully the designer applies the basic principles that guide all creative planning.

1. **Balance-** The visual equilibrium of different garden elements is known as balance in landscapedesign. It is very important to maintain the balance on both sides of central axis.
2. **Scale and Proportion-** Scale is an important landscape principle. Any element placed in garden without scale looks very awkward. A narrow step leading to a wide terrace is completely out of scale. The steps in garden should not be broader than those inside the buildings but should have deep treads and low riser also. Proportion in a garden may be defined as definite relationship between masses. Proportion is the relation of one thing to the other in magnitude. A rectangle having 5:8 ratios is considered to be a pleasing proportion as this ratio comes down the form looks neither square nor rectangular and design becomes undesirable.
3. **Rhythm/Harmony-**
Repetition of same object at equal distance is called rhythm. It can be created through shape, progression of sizes or continuous line movement. It should not be break.
4. **Unity:** Unity in a garden is very important as when it is achieved it will improve the artistic look of the garden. Different components of the garden should merge harmoniously with each other. The aim is to give the impression and overall effect of garden rather than some special features.
5. **Accent/Emphasis:**
Emphasis is created in the garden to avoid monotonous view. It is a method to stress the most important thing. This also serves as center of attraction.
6. **Simplicity:** The design of gardens should be simple which should be understand by man and nature. The various elements and features should be placed in such a way that it should look pleasant rather than confusing to the people.

CHAPTER3

Landscape uses of trees, shrubs and climbers

Landscape uses of trees, shrubs and climbers

Tree is a perennial plant having distinct trunk and crown at the top

Logical meaning of each letter of tree

- T- Temperature and microclimate moderation
- R- Removal of air pollutants
- E- Erosion control
- E-

Energy conservation

Uses of tree

Trees combat the greenhouse effect: Global warming is the result of excess greenhouse gases, created by burning fossil fuels and destroying tropical rainforests. Heat from the sun, reflected back from the earth, is trapped in this thickening layer of gases, causing global temperatures to rise. Carbon dioxide (CO₂) is a major greenhouse gas. Trees absorb CO₂, removing and storing the carbon while releasing the oxygen back into the air.

Trees clean the air: Trees absorb odors and pollutant gases (nitrogen oxides, ammonia, sulfur dioxide and ozone) and filter particulates out of the air by trapping them on their leaves and bark.

Trees cool the streets and the city: Average temperatures in Los Angeles have risen 6°F in the last 50 years as tree coverage has declined and the number of heat-absorbing roads and buildings has increased.

- **Trees cool the city by up to 10°F,** by shading our homes and streets, breaking up urban “heat islands” and releasing water vapour into the air through their leaves.
- **Trees conserve energy:** Three trees placed strategically around a single-family home can cut summer air conditioning needs by up to 50 percent. By reducing the energy demand for cooling our houses, we reduce carbon dioxide and other pollution emissions from powerplants.

Trees save water: Shade from trees slows water evaporation from thirsty lawns. Most newly planted trees need only fifteen gallons of water a week. As trees transpire, they increase atmospheric moisture.

Trees help prevent water pollution: Trees reduce runoff by breaking rainfall thus allowing the water to flow down the trunk and into the earth below the tree. This prevents storm water from carrying pollutants to the ocean. When mulched, trees act like a sponge that filters this water naturally and uses it to recharge groundwater supplies.

Trees help prevent soil erosion: On hillsides or stream slopes, trees slow runoff and hold soil in place by binding the soil particles with their roots

Tree improve fertility of soil by adding organic manure in the form of leaves every year

Trees help prevent check air pollution and noise pollution

Trees shield children from ultra-violet rays: Skin cancer is the most common form of cancer in the United States. Trees reduce UV-B exposure by about 50 percent, thus providing protection to children on school campuses and playgrounds - where children spend hours outdoors.

Trees provide food: An apple tree can yield up to 15-20 bushels of fruit per year and can be planted on the tiniest urban lot. Aside from fruit for humans, trees provide food for birds and wildlife.

Trees heal: Studies have shown that patients with views of trees out their windows heal faster and with less complications. Children with ADHD show fewer symptoms when they have access to nature. Exposure to trees and nature aids concentration by reducing mental fatigue.

Trees reduce violence: Neighbourhoods and homes that are barren have shown to have a greater incidence of violence in and out of the home than their greener counterparts. Trees and landscaping help to reduce the level of fear.

Trees mark the seasons: Is it winter, spring, summer or fall? Look at the trees.

Trees create economic opportunities: Fruit harvested from community orchards can be sold, thus providing income. Small business opportunities in green waste management and landscaping arise when cities value mulching and its water-saving qualities. Vocational training for youth interested in green jobs is also a great way to develop economic opportunities from trees.

Trees are teachers and playmates: Whether as houses for children or creative and spiritual inspiration for adults, trees have provided the space for human retreat throughout the ages.

Trees bring diverse groups of people together: Tree plantings provide an opportunity for community involvement and empowerment that improves the quality of life in our neighbourhoods. All cultures, ages, and genders have an important role to play at a tree planting or tree care event.

Trees add unity: Trees as landmarks can give a neighborhood a new identity and encourage civic pride.

Trees provide a canopy and habitat for wildlife: Sycamore and oak are among the many urban species that provide excellent urban homes for birds, bees, possums and squirrels.

Trees block things; Trees can mask concrete walls or parking lots, and unsightly views. They muffle sound from nearby streets and freeways, and create an eye-soothing canopy of green. Trees absorb dust and wind and reduce glare.

Trees provide wood: In suburban and rural areas, trees can be selectively harvested for fuel and craft wood.

Trees increase property values: The beauty of a well-planted property and its surrounding street and neighborhood can raise property values by as much as 15 percent.

Trees increase business traffic: Studies show that the more trees and landscaping a business district has, the more business will flow in. A tree-lined street will also slow traffic – enough to allow the drivers to look at the store fronts instead of whizzing by.

- **Specimen tree:** Such trees are planted singly for their attractive shape, beautiful foliage, flowers or for drooping branches which reflect humbleness. Ex: Araucaria cookii,
Callistemon lanceolatus, Salix babylonica, Cassia fistula, Plumeria alba, Cassia nodosa
- **Shady trees:** Such trees have mostly round canopy or umbrella crown. Leaves are large and dense so that no or very little sun is allowed underneath them. Ex: Azadirachta indica, Ficus religiosa, F. benghalensis, F. infectoria, Mangifera indica
- **Flowering trees:** produce colourful and beautiful flowers. Ex: Bauhinia variegata, Callistemon lanceolatus, Cassia fistula, Delonix regia, Plumeria alba, Butea monosperma
- **Tree for avenue or roadside:** Planted for shade or flowers. Ex: Cassia fistula, Grevillea robusta, Jacaranda acutifolia, Ficus infectoria, Kigelia pinnata

- Screening purpose: When tall upright trees are planted very close together to give an ultimate look of curtain or screen. Such trees are planted to hide some objects or sides. Ex: *Grevillea robusta*, *Eucalyptus* spp., *Populus* spp., *Polyalthia longifolia*, *P. pendula*
- Fragrant flowers: ex: Kanak champa (*Pterospermum acerifolium*), Pagoda tree (*Plumeria* spp.), Bara champa (*Magnolia grandiflora*), Swarn champa (*Michelia champaka*)
- For checking air pollution: *Morus* spp., *Poplar hybrida*, *Plumeria acutifolia*, *Ficus infectoria*

Shrub

- A shrub is distinguished from a tree by its multiple stems and shorter height, usually under 6 m (20 ft) tall.
- Plants of many species may grow either into shrubs or trees, depending on their growing conditions. Small, low shrubs, generally less than 2 m (6.6 ft) tall, such as lavender, periwinkle and most small garden varieties of roses, are often termed subshrubs or bushes.
- Shrubs are woody, perennial plants that generally grow to a height of 12 feet but can sometimes reach 20 feet or more.
- Among the hundreds of varieties of shrubs, two main types emerge -- deciduous shrubs, which lose their leaves in winter, and evergreens, which don't.
- Many varieties of both produce berries and small fruit, while others produce flowers of different colors, shapes and scents.
- In the landscape, they can serve as windbreaks and privacy screens, as ornament, or as an important food source for birds, small animals, insects and other wildlife.

Purpose of planting shrubs

- To enhance the beauty of surroundings
- To provide fragrance in the garden
- To act as boundary of property line and provide liveliness to the garden
- Planted for screening purpose to hide unwanted places
- Planted to divide the area of the garden such as ladies corners or children's corner

Classification

Flowering Shrubs: Produce very attractive and spectacular flowers which are grown for mass effect and carpetting purposes. Ex: *Hibiscus rosa-sinensis*, *Hibiscus mutabilis*, *Caesalpinia pulcherrima*, *Bougainvillea* spp., *Ervatamia divaricata*, *Nerium indicum*, *Calliandra*

For Foliage: grown in the garden for handsome and richly variegated foliage. Ex:
Acalypha tricolour, Nandina domestica, Codium variegata, Manihot variegata

For Flowers and Foliage: Some flowers have handsome foliage and produce good flowers too. Ex: **Bougainvillea, Buddleia asiatica, Buddleia madagascariensis, Hamelia patens**

For Fragrant Flowers: **Cestrum nocturnum, Cestrum diurnum, Murraya panniculata, Jasminum sambac, Jasminum auriculatum**

Climbers

- **Climbers**—group of plants which have weak stems and ability to climb up the support with the help of modified organs for sunlight and air.
- Climbers possess different modified organs which help in climbing of the support
- They are tendrils : **Antigonon leptopus, Bignonia gracilis, Pyrostegia venusta**
- Thorns : **Bougainvillea**
- Roots and rootlets: **Campsis grandiflora, Ficus repens** by secreting sticky substances from growing points
- Twiners differ from climbers in the way that they don't possess such modified organs but twine around the support, cover it and reach the top

Uses of Climbers

- Create natural and thick screen
- Covering ugly objects
- Create privacy
- Covering slopes as ground cover
- Shading after training over pergolas
- Avenue planting
- Topiary
- Integrating house with the garden
- Softening harsh masonry walls
- To supplement and filling bare spots in the garden
- To give added interest by training on trees
- To cover up patio

Selection of climbers

- There is different situation in the garden like sunny, partial shade and different structures according to which suitable types can be selected
- For sunny situation: *Pyrostegia venusta*, *Quisqualis indica*, *Antigonon leptopus*, *Bougainvillia*
- For partial shade: *Clerodendron splendens*, *Petreavolubilis*
- Heavy Climbers: Produce luxuriant vegetative growth and grow very vigorously. They cover large area and are suitable for covering bigger area
- Eg: *Antigonon leptopus*, *Bignonia magnifica*, *Bougainvillia*, *Pyrostegia venusta*, *Clerodendron splendens*
- Light climbers: These climbers make sparse vegetative growth and remain light in spread. These are suitable for limited spaces. eg. *Lonicera japonica*, *Clitoria ternatea*
- Climbers for fragrant flowers: *Jasminum grandiflorum*, *J. officinale*, *Hiptage benghalensis*
- Climbers for pots: *Bougainvillia*, *Clitoria ternatea*
- Making hedge: *Clerodendron inerme*, *Bougainvillia*
- Indoor decoration: *Pothos*, *Monstera deliciosa*, *Philodendron* sp., *Asparagus* spp.,
- For screening: *Vernonia elegans*, *Pyrostegia venusta*
- Annual Climbers: *Ipomea lobata*, *Clitoria ternatea*

CHAPTER4(i)Rose

Introduction: Top most cut flower in domestic and International market. Symbol of beauty, love and fragrance. Popularly known as queen of flowers. Great diversity in plant growth and flower colour, cultivated for cut and loose flowers, oil extraction, rose water, flavouring agent and drying purposes, hips of some rose species are rich in vitamin C, petals are used for preparing Gulkand and Pankhuri. It belongs to family Rosaceae and is originated from the Himalayan regions of Europe and north America.

Varieties used for cut flower purpose: Christion Dior, Avon, Crimson Glory, Grand Gala, First Red, Dallas, E.G. Hill, Happiness, Confidence, picture, First Prize, Sonia, Kiss, Europe, Royal, Nobles, Pink, Aristocrat, Better Times, Raja Ram Mohan Roy, Mercedes, Jazz, Orange Delight, President Herbert, Golden Time, Golden Gate, Golden Rapture, Golden Giant, Aalsmeer Gold, Tushar, June Bride, Prestige, Vivaldi, Verselia, Florence.

Climate: Requires good light throughout the year. Temperature range of 15°C to 28°C and 75% relative humidity is ideal for quality rose growing. High relative humidity may cause more incidences of disease and pest while lower relative humidity results in reduced size of leaves, flowers and stems.

Soil: Sandy loam to clay loam soil, deep and well drained soil rich in organic matter having pH 5.5 to 6.3. water holding and nutrient holding capacity of the soil should be good.

Propagation

Cuttings: Matured current season shoots are selected for cuttings. The cut ends are dipped in root inducing hormone and planted in beds. Usually miniature, shrub, climber and oily yielding roses are propagated by this method.

Micropropagation: High frequency clonal propagation from axillary buds and shoot tip culture produce large quantities of chosen variety in a short span of time.

Budding: The most common and preferred method in Hybrid Tea roses, done in February-March, dormant eyes on a scion of chosen variety are budded either by T or inverted T or I method of budding on a root stock, commercialy used rootstock is Rosa indica var odorata.

Cultural operations

Pruning: Done during first week of October under north Indian conditions and in last week of June and again in last week of November under Bangalore conditions. However, in case of essential oil yielding varieties of Rosa damascena, pruning is done from last week of December to the beginning of January. The height of pruning varies from 30-45 cm from ground level.

Pinching: Part of terminal growing portion of stem is removed to promote axillary branching and to delay maturity of buds.

Wintering: In this operation, the root is exposed in first fortnight of October to provide rest to the plants for further quality flower production.

Stem bending: Five months after planting, the stems are bent out in such a manner that the angle between original and bent shoot is less than 90°.

Manure and fertilizers: In addition to the basal dose of well decomposed FYM (50 t/ha), rose requires 200-400 kg of N, 150 kg/ha of each P and K/ha. Nitrogen dose may be split into two, once at the time of pruning and the second dose after 20 days of pruning. The basal dose of fertilizers may also be supplemented with foliar feeding, consisting of 2 parts urea, 1 part dihydrogen ammonium phosphate, 1 part potassium phosphate and 1 part potassium nitrate using 3 g of this mixture/l of water after one week or 10 days till flowering.

Diseases

Fungal: Die-back, Black spot, Powdery mildew, Botrytis blight and Leaf blight.

Insect pests: Mites, Beetle, Scale, Thrips, Jassids, Mites, Mealy bugs, Aphids and Nematodes.

Harvesting: For distant markets, harvested at tight bud stage and for local markets, buds should be harvested at more advanced stage of opening.

Grading and packaging: After cooling, stems shifted to air-conditioned grading room. Healthy stems are sorted out in different grades according to the stem length, cultivar and condition of the flower. The graded stems are made into bundles of 20 each, tied loosely with rubber band and wrapped with 2 ply soft corrugated paper and precooled fibreboard boxes.

Yield: Under open conditions, about 10-20 flower stems can be obtained in Hybrid Tea roses for cut flower purpose.

CHAPTER4(ii)

Gerbera



Introduction: It is popularly known as Barberton daisy, Transvaal daisy, Veldt daisy, African daisy and Hilton daisy. Gerbera is a popular cut flower which is ideally suited for flower beds, borders, pots, window boxes and gardens. It belongs to family Asteraceae and is originated from tropical Africa.

Varieties: Black Heart, Calcutta Pink, Calcutta Red, Glory, Golden Gate, Gold Spot, Greenish Yellow, Kalimpong Yellow, Orange Glame, Ornella, Optima, Pink Elegance, Pink Star, Pride of Sikkim, Priyadarshini, Rosabella, Ruby Red, Saffron, Sangria, Savannah, Sunanda, Thalassa, Tiramigu, Tirramissa, Tonneke and Twiggy.

Climate: Gerbera like sunny situation in mild weather. The better quality of flowers was obtained when temperature was less than 25°C and higher temperature reduces

number and size of flowers. It requires a RH of about 80% all the year round.

Soil: A well-drained, rich, light, neutral or slightly alkaline soil is most suitable for gerbera production. It requires a soil pH range of 6.0-7.0.

Propagation: Gerbera is propagated through seeds and vegetative means. Seed propagation, however requires longer period to produce flowers and also is not always satisfactory, since cross pollination produces a great deal of variation in variety. Among the vegetative means, multiplication through the division of clumps is the most common.

Cultural operations

Weed control: About 2-3 hand weeding should be done at 15 days interval and chemical like trifularin, EPTC, nitrofen and diphenamid after one day of transplanting markedly reduced the growth and population of weeds.

Mulching: It can be done with the help of straw and polythene sheets. It gives a good control of weeds and also helps to conserve soil moisture. The main disadvantage is that, it serves as a home for various insect and pests.

Manure and fertilizers: Till 2-3 weeks after planting, no fertilizers are applied. From 3-12 weeks, N:P:K with the ratio of 20:20:20 should be applied at 0.75 g/l/day and from 12 weeks onwards, 15:8:35 at 1-1.5 g/l/day can be applied.

Diseases

Fungal: Foot rot and Root rot, Anthracnose, Blossom blight and Powdery mildew.

Insect pests: White fly, Leaf miner, Mites, Aphids and Nematodes.

Harvesting: Flower are generally cut when the outer two row of disk florets are perpendicular to the stalk. Flowers should be pulled and placed immediately in water.

Yield: The yield under greenhouse is around 200-250 flowers/m²/year of which 85% are of first grade quality. However, yield of flower is about 120-150/m²/year under open cultivation of which only 15-20% of flowers are of first grade quality because of fluctuation in temperatures and higher light intensity.

CHAPTER4(iii)**Carnation**

Introduction: Commercial cut flower with excellent vase life and sweet fragrance, very light in weight and regain its shape after placing in vase solution, commercially utilized for extraction of oil and perfumes. The carnation is a native to the Mediterranean region and belongs to family Caryophyllaceae.

Varieties

Standard varieties: Corleone, Lipstick, Design, Empire, Romana, Dark Tempo, White Tundra, Ariane, Cobra, Papaya, Monopole, Peterson Red, Scania Red, Scania White Sim, Nora, Red Diamond, Peppermint Lace, Pink Ice.

Spray varieties: Rony Anony, Rhodes, Light Pink, Barbara, Bagatel, Silvery Pink, Natila, Celins, White Barbara, Furove, Star Dust, Krystie.

Climate: Standards carnation perform well in cooler climate, whereas spray types can grow better at higher temperature. Carnation is a long day plant. Early flowering can be taken during long day than short days. Optimum night temperature during winter, spring and summer is 10°C to 11°C, 12.7°C and 13.0°C to 15.4°C respectively. Plants grows well when relative humidity is 50-60%.

Soil: Sandy loam soils with proper drainage and rich in organic matter content with a pH of 6.0- 6.5 are most ideal.

Propagation

Terminal cuttings: NAA treated (250 ppm) cuttings (10-15 cm long) having 4-5 pairs of leaves are broken from the mother plant and planted in sand or in coco-peat in mist chamber.

Micropropagation: Propagation of carnation in large scale through tissue culture has been standardized.

Cultural operations

Weed control: Weeding of beds needs to be done regularly. Application of fluchloralinherbicide@0.96kg/ha or pendimethalin(30%EC)at0.90kga.i./ha were found very effective to control the weeds of carnation.

Pinching: There are three ways of pinching in carnation.

Single pinch: It is done once at 5 node stage by retaining 4-5 shoots for obtaining an early crop. Usually done to get early crop.

Pinch and a half: It is done to provide steady production of flowers but reduces the amount of first crop. In this type of pinch, the main stem is pinched and later when the resulting shoots are long enough, half of largest shoots on each plants is pinched.

Doublepinching: It is done first by doing single pinch followed by another pinching of all the shoots when they are 6-8 cm in length. It is done to delay flowering.

Deshooting: Unwanted shoots on the flowering stems are removed with the hands when they are about 2-3 cm long. This is done to get an healthy growth of a single plant.

Disbudding: Important operation in standard varieties. The side buds to be removed just after appearance without damaging the leaves and the stems.

Calyx banding: The problem of calyx splitting can be reduced by placing a band around the calyx of the flower bud when they have just started opening.

Manure and fertilizers: At the time of land preparation sufficient quantity of organic manure must be added. A basal dose of N, P, K, at the rate of 20: 20: 10 g/ m² is applied three weeks after planting. Fertigation is done with N at 100 ppm and K at 140 ppm twice in a week along with other macro/micronutrients like Ca, Mg, Fe, B, Mn, Cu and Zn.

Diseases

Fungal: Wilt, Alternaria leaf spot and blight, Stem rot and Grey mould.

Insect pests: Variegated cutworm, Green peach aphid, Caterpillars, Thrips, Red spider mite and Nematodes.

Physiological disorders

Calyx splitting: Calyx may split down either half or completely. A number of factors like genetic, environmental, nutritional and other cultural practices are responsible.

Slab side: This disorder may arise during cooler period and buds do not open evenly, so that petals protrude on one side only.

Harvesting: The best time for harvesting is in the morning. The flowers are harvested by either or cutting off the stem with a sharp knife or small shears. The cut flower should be immediately placed in sodium hypochloride solution (15% a.i.) at 1 ml/10 litre water.

Grading and packaging: The fully opened flowers of standard cultivars may be protected by inserting the individual flowers in polyethylene sleeves. The bunches are precooled at 2-3 °C and packed in fibre board boxes (30 cm height x 50 cm width x 122 cm length) for transport.

Yield: Generally, 200 flowers/m² can be obtained from standard type, while 250 flowers/m² can be taken from spray type.

CHAPTER4(iv)**Lilium**

INTRODUCTION: Lilies are very useful cut flower as well as bed or border plant for giving mass effect. Shorter varieties are planted in containers. In China, bulbs of tiger lily are preferred as food due to its specific taste. Lilaline, an alkaloid is diuretic, emmenagogue, emollient and expectorant. The flowers are carminative. They are used to strengthen the eye lid muscles and are recommended in the treatment of myoptic astigmia.

VARIETIES**Asiatic cultivars**

Alaska, Lucyda, Marbelle, Pulsar, Sancerre, Ventoux, Apledoorn, Bangalope, Elite, Loreto, Menton, Prato

Oriental cultivars: Casa Blanca, Dream, Mont Blanc, Montreal, Primeur, White Sheen, Corina, Jazz, Red Carpet, Strangazer

CLIMATE: To obtain the best quality of lily flowers the day temperature range should be 15-20°C, whereas night temperature of around 8-10°C is suitable. Lilies require some shading. For cut flower production, a 30-40% shade cloth is common. Under Indian conditions during summer months use of shading net to cut off 75% light and 50% during winter is beneficial.

SOIL: Soil used for cultivation of Lilium should be good in structure particularly top layer. Sandy loam soil is found suitable for its cultivation. The growing medium must be porous for good aeration and water drainage. A soil pH of 6.0 to 6.5 is recommended.

PROPAGATION: Lilies can be multiplied by seeds, scales, bulblets and bulbils. Micro propagation has also been a successful method for large scale multiplication.

CULTURAL OPERATIONS

Weed control: Chloropham at 3.5 l/ha and propyzamide at 2.25 kg/ha are found beneficial to control the wild population except leguminous weeds. Application of simazine at 3-4 weeks of emergence is found effective to control the weeds.

Staking: Staking or netting of lily plants is required when they become 50 cm tall. Netting is to be done at 50-60 cm intervals. It reduces breakage of stems.

MANURE AND FERTILIZERS: Application of nutrients is essential for proper growth and flowering of Lilium. Lilies responded well with the application of nitrogenous fertilizer.

Nitrogen should be applied at 1 kg of calcium ammonium nitrate/100 m² after three weeks of planting of bulbs. If plants are weak and showing deficiency of N then top dressing offast release nitrogen (Urea) @ 1 Kg/100 m² may be done before three weeks of flower harvesting.

DISEASES

Fungal: Foot rot, Fusarium scale rot and Botrytis blight

Bacterial: Soft rot

Viral: Tulip breaking virus and Cucumber mosaic virus

INSECTPESTS: Aphid, Fuller rose beetle, Stalkborer, Thrips, Bulbmite and Nematodes

HARVESTING: Flowers of lily are harvested when the first lowermost bud shows full colour but has not yet opened. The spike of flowers is generally cut 15 cm above the ground level so that the development of bulb may continue in the soil.

GRADING AND PACKAGING: After harvesting, flowers are graded as per the number of flower buds per stem, length and firmness of stem. In the Netherlands they are graded by the lowest number of calyx per stem and the highest number of calyx per stem. Removal of anthers from open bloom is important operation to prevent the spoiling the flower or any surfaces on which it might fall. The foliage must be removed at 10 cm above from the bottom, which helps in packaging. The lilies are bunched in a bundle of six stems.

YIELD: The yield of flowers greatly varies according to cultivar, package of practices adopted during cultivation and climatic conditions. The average production of marketable spike is 1,00,000 to 1,12,500/ha, whereas bulb yield is 1,25,000 to 1,50,000/ha.

CHAPTER4(v)**Orchid**

Introduction: Orchids are perennial, terrestrial, epiphytic, saprophytic or inter-mediate herbs with rhizomes or pseudobulbs or tuberous or aerial roots. Orchid is the most diverse flowering plant utilized for cut flower production and as potted plant. Orchids are excellent for garden and can be grown in beds, pots, baskets, split hollows of bamboo pieces or even ion tree bark. The leaves of *Vanda roxburghii* is used against rheumatism. *Habenaria*, a terrestrial genus of orchid also possess medicinal properties. Vanillin produced from *Vanilla planifolia* is used in flavouring industries. Pseudobulbs of *Cymbidium madidum* and *Dendrobium speciosum* are used as food. Orchids are available in abundance in tropics and temperate regions. It belongs to family Orchidaceae and is originated from Indo Malayan and Tropical America.

Classification

Monopodials: Main axis continues to grow year after year and bears flowers on lateral branches. Following genus belong to this group-

Arachnis: *Arachnis* is generally known as scorpion orchid or spider orchid. Flowers appear almost all the year round. They prefer bright sunlight and high humidity for growth and development.

Renanthera: This is also a sun loving orchid, having good commercial value. It is grown in the southern districts of Kerala, especially in the coastal belt.

Phalaenopsis: *Phalaenopsis* grow best at low temperature, light intensity and lesser humidity. Flowers are flat with three lobed lips. They are borne long sprays in large number.

Vanda: Based on the shape of leaves, there are two types of Vandas; the strap leaved and the terete (pencil like) leaved.

Sympodial: Main axis comprises of annual portions of successive axis each of bears scale leaves and terminal flowers. Following genus belong to this group-

Cattleya: These are also of two types based on the leaf types, the unifoliate which produces single leaf from each pseudo bulb and bifoliate which produces two or even three leaves. The

pseudobulbs and the flowers are usually larger in size. They require partial shading under tropical conditions. There are more than 50 species.

Dendrobium: Dendrobium is the second largest genus of orchids consisting around 1340 species. They produce pseudobulbs or slender canes out of the underground rhizomes. They prefer partial shade and high humidity. Several commercial varieties are found to perform extremely well under tropical conditions.

Varieties New Pink, Hieng Beauty, Emma White, Kasem White, Sonia-28, Sonia- 17, White Nern, Boonchoo Gold, Kanchana Green, Jacqueline Thomas, Madam Vipor, Pink Tips, Banyat Pink, Sakura Pink and Sabine.

Climate: Irrespective of the genera, all orchids need the morning sunlight. Arachnis, Vanda, etc. can tolerate very high light intensities of the tropics, whereas, the light requirement of Cattleya is lower. It is still lower in the case of Dendrobium and very low in Phalaenopsis.

Although various species vary in their individual requirement of optimum temperature, most of the cultivated orchids thrive in a day temperature varying from 15.5 to 21°C and night temperature of 10 to 15.5°C. Orchids in general prefer high humidity. Monopodial require high humidity (upto 70%), while sympodial require comparatively less humidity (40-50%).

Soil: Areas with very high slope are not desirable. Though the soil quality is not a problem for epiphytic orchids, saline soils may be avoided. In the case of sympodial hybrids that are easily killed by excess moisture, resulting from deep burial of the plants, the media serve to conserve moisture, which on evaporation favours the plants. In general, the media support the plants and supply moisture rather than providing nourishment as is the case with most of the other plants.

Propagation

Propagation of monopodial orchids: Stem cuttings, Flower stalk cuttings, and Layering and Micropropagation.

Propagation of sympodial orchids: Division, Off-shoots or keikis, Backbulbs and Micropropagation

Potting and repotting: Repotting with porous compost containing barks, cocochips, cocopeats, leaf mould, sawdust, chopped leaf ferns or brick pieces. Repotting every after 2-4 years as indicated by the bulbs filling the pot, breaking down of potting mixture and if a plant is not able to produce 1-2 bulbs each year from each bulb that grew the previous year. Fresh air and good circulation. Leaves should move gently in a light breeze. Training with bamboo sticks or yoyo to keep the spikes upright position

Cultural operations

Weed control: Hand weeding must be done very carefully. A combination of direx 4L (1.5 kg a.i./ha) and ronstar WP (2.2 g/l) applied either as a potting component or as a spray application can provide a wider spectrum of weed control than either chemical alone.

Replanting/repotting: The plant is gently shaked out of pot. If the roots are clinging to the inside of the pots tightly, a sharp knife is run around the inside wall of the pot to loosen the roots. If the plants have sufficient number of shoots, they are divided and repotted separately. Before planting, the dead bulbs and dried roots should also be removed.

Regulation of light: Providing optimum shade is an important aspect of cultivation of orchids. Maximum spike production occurs in 25% double level shading. Fifty per cent single level shading is distinctly superior to all other treatments with respect to the number of flowers per spike. Vase life also increases in 25% and 50% double levels of shade.

Ventilation: Air movement helps to evaporate stagnant water trapped during watering, where fungi and bacteria breed.

Damping: To imitate these conditions, damping is done by spraying the floors, walls and staging of the house. Damping in winter should be done with a rising temperature.

Spraying: Spraying is done in morning and afternoon during warm weather. Plants like Cymbidium delight in heavy spraying in hot weather.

MANURE AND FERTILIZERS: A fertilizer complex containing nitrogen, phosphorus and potash in equal proportion (like 17:17:17 complex) is ideal for general application. Instead of a readymade mix or complex fertilizer, a mixture can be readily prepared using laboratory chemicals. Ammonium nitrate, orthophosphoric acid and potassium nitrate (to supply N, P and K respectively) can be used for this. During vegetative phase a 30:10:10 combination of N, P and K should be used which may be changed to 10:20:20 formulation during flowering stage. A concentration of 0.2% should be sprayed twice a week.

Diseases

Fungal: Leaf spot, Pythium black rot and flower blight.

Bacterial: Bacterial soft rot

Viral: Blossom brown necrotic streak, Mosaic flower break, Cymbidium mosaic, black streak or Cattleya leaf necrosis and Odontoglossum ring spot.

Insect pests: Aphids, Orchid weevil, Orchid bulb borer, Orchid fly, Orchid mealybug, Cattleya midge, Cattleya weevil, Dendrobium borer, Scales, Thrips, Mites, Slugs and Nematodes.

Harvesting: Correct stage of harvesting is essential as it not only influence keeping quality, but also adds to the beauty of the spike. Cattleya should be harvested 3 to 5 days after the bud split or dehisce. Dendrobium is harvested when two or three buds are still unopened. The weather conditions prevailing at the time of harvesting influence the exact stage of picking. During the warm weather, the blooms can be harvested at an earlier stage of development. Tagging the buds each day facilitate cutting process. Cymbidium can be cut with the help of sharp blade when they are fully open. Individual flower or the entire spike is harvested at one time. Flowers are harvested twice a week during peak production period and once a week during low periods. Harvesting is done when 30 to 40% of the flowers are open. Harvesting should preferably be done in evening. The knife used for harvesting should be dipped in antibiotic mixture to prevent disease transmission.

Grading and packaging: Grading is done on the basis of number of flower/buds, uniformity of flowers colour, maturity and the number of open flowers compared with number of buds, flower blemishes, stem length, stem curvature, missing floral parts, presence of twisted or deformed flowers. After grading, hydrating, grouping and sleeving take place. To keep flowers hydrated, a small piece of moist cotton is kept at the base of each stem, covered with small piece of plastic film (6 x 6 cm). Packing can be carried out in single spray or in bunches with stem base aligned. Five or ten sprays in a bunch are standard. Bunches are placed in a clear plastic sleeves. After sleeving, the flowers packed in fibre board trays are then packed in master cartons. The cartons should have sufficient number of holes to facilitate aeration. Flowers are shipped either as intact spray or individual flower.

Yield: In general orchid has a long gestation period and it produces flowers after 3-4 years of plantation. Yield of orchid flowers varies according to genus. Dendrobium gives a yield of 1-2 spikes/plant. The genus Oncidium bears 5-6 stems/plant, producing 30-50 flowers/stem. Genus Vanda has an average yield of approximately 4 sprays/plant bearing 10-15 flowers per spray. Generally, genus Cymbidium may give a yield of upto 2500 spikes from fourth year onward, reaching upto 5000 to 7500 spikes per 500 m² area in the fifth and sixth year, respectively.

CHAPTE5(i)**Gladiolus**

Introduction: It is an important commercial cut flower, ideal for bedding, for flower arrangement, in bouquets and for decorations. It belongs to family Iridaceae and is originated from south Africa.

Varieties: Eurovision, Pink Friendship, Snow Princess, Rose Supreme, Rose Spire, Suchitra, Peter Pears, Mayur, White Prosperity, Jester and Subhangini.

Climate: Optimum growth of gladiolus occurs at temperature between 10-25°C. Long day treatments delay flowering but improves bloom quality. Long day condition of 12-14 hrs photoperiod increases number of florets, spike length and flowering percentage.

Soil: Sandy loam soil with pH between 6.0 to 7.0 is ideal. Gladiolus plants are sensitive to alkaline and degraded soil.

Propagation: Gladiolus is propagated by seed, by vegetative means (corms, cormels) and by micropropagation.

Manure and fertilizers: Organic manure should be mixed through the top soil before planting to improve the structure of the soil. Nitrogen should be applied at 300 kg/ha which may be reduced in medium and heavy soils. It is applied in two doses, first at 3 leaf stages and second at 6 leaf stage. Phosphorus should be given as basal dose ranging from 150-200 kg/ha depending upon soil test. Gladiolus requires around 120-

150 kg K₂O/ha at the time of planting of corms. Iron deficiency can be corrected by spraying ferrous sulphate at 0.2 per cent, twice or thrice at 10 days interval.

Diseases

Fungal: Fusarium wilt, Storage rot, Dry or Neck rot, Botrytis blight, Flower rot and Leaf spot.

Bacterial: Leaf spot

Insect pests: Aphids, Thrips, Borers, Loopers and Nematodes.

Physiological disorders:

Tip burn: This physiological disorder occurs due to high levels of aerial fluorides in the atmosphere. A spray of blitox 50 WP (0.3%) should be given at initiation of symptoms and repeated once more, if required.

Geotropic bending of spikes: This is primarily due to the lateral downward movement of auxin and its accumulation on the lower portion of the spike. To prevent bending of tips, the spikes should be held vertically in storage as well as during transportation.

Harvesting: Spikes are ready for harvest in 60-90 days after planting and continue for about a month. For export and distant market, it should be harvested at the tight bud stage or when basal 1-2 florets shows colour. Harvesting should be done in morning or evening hours when temperature is mild. For local market spikes are harvested when basal floret is fully opened. Cut is given above the top leaf sheath with the help of sharp secateur/knife. The cut spikes are immediately kept in a bucket containing water. While cutting spikes 2-3 bottom leaves should be left.

Postharvest management: Spikes can be pulsed with 20 per cent sucrose plus 8-HQC (200 ppm)/ aluminium sulphate (300 ppm) or sodium hypochlorite (50 ppm) for improving vase life.

Grading And Packaging: The spikes are graded before marketing. According to Society of American Florists, gladiolus should be graded as follows:

Grade	Spike length (cm)	Minimum number of florets
Fancy (Blue)	>107	16
Special (Red)	96-107	14
Standard (Green)	81-96	12
Utility (Yellow)	<81	10

Graded spikes are made into bunches of 10-12 and loosely tied with rubber band and packed in cardboard boxes. Empty tube light boxes can be used for this purpose and each such box can accommodate 250 to 300 quality spikes. For export purposes, spikes need to be precooled at 4-5°C for 72 hours under dry conditions. Uncooled spikes can be transported for 24-48 hours at 20-25°C. Transportation medium depends on distance to market.

Yield: Approximately yield of flower spike would be around 2,00,000-3,00,000/ha depending on planting density, cultivar, corm size and management practices.

CHAPTE5(ii)**Tuberose**

Introduction: It is commercially grown as cut flower, loose flower as well as for its potential in perfume industry. The flowers of tuberose are used for artistic garlands, floral ornamentals, bouquets and button holes. It belongs to family Agavaceae and is originated from Mexico.

Varieties: Variegated, Calcutta Single, Calcutta Double, Rajat Rekha, Swarna Rekha, Shringar, Suvansini, Prajwal and Vaibhav.

Climate: Tuberose grows in mild climate without extreme of high or low temperature. For its luxuriant growth, it requires high humidity and moderate temperature. The double type cultivars prefer a cooler temperature than the single type. Tuberose grows well in sunny situation. The optimum temperature range for growth and development is 20°C to 30°C.

Soil: Loam and sandy loam soil with good aeration and drainage are considered ideal for its successful cultivation. Well drained friable soil of atleast 45 cm depth, rich in organic matter and sufficient moisture retaining capacity is good for proper plant growth. A mixture of garden soil, farmyard manure and leaf mould in the proportion of 2:1:1 should be used for pot culture of tuberose.

Propagation: Tuberose is generally propagated vegetatively by means of bulbs. Seeds are difficult to germinate. To get virus-free material or for a very rapid multiplication, tissue culture method is adopted.

Cultural operations

Weed control: Generally, weeding is done by hand. Pre-emergence application of Stomp (pendimethalin 30 EC at 1.25 kg a.i./ha) caused maximum reduction of weeds and also produced higher yield of quality flowers.

Manure and fertilizers: Fertilizer application at 200 kg N, 150 kg P and 150 kg K/ha is recommended to obtain maximum number of spikes. Nutrition dose comprising of 200 kg N, 150 kg P and 200 kg K/ha has been found optimum for tuberose under Pune conditions.

Diseases

Fungal: Stem rot or Sclerotial wilt, Leaf blight or Botrytis blight and Alternaria leaf spot.

Bacterial: Flower bud rot.

Insect pests: Grasshopper, Weevil, Aphid, Red Spider Mite, Thrips, Borers and Nematodes.

Harvesting: Flowering of tuberose starts 2 to 4 months after planting. For its marketing as cut flower, the tuberose is harvested by cutting the spike when 1-2 pairs of flowers open on the spike preferably in the morning before sun rise or late in the evening. About 4-6 cm basal portion has to be left to allow the growth of bulb. For loose flower production and extraction of concrete/absolute only individual open flower is harvested early in the morning from the flower spike. On an average, 2 to 4 flowers per spike can be plucked everyday.

Grading and packaging: These spikes are graded according to the stalk length, length of rachis, number of flower per spike and weight of spike. For making bouquet and room decoration, long spikes are preferred and are sold in bundles. Each bundle contains 50-100 spikes. Bundle of spike is packed in rectangular bamboo baskets lined with cloth. For long distance transport, corrugated cardboard boxes are used for packaging. The size of boxes varies in accordance with spike length. As a guideline the minimum length of the box should be about double the width and its width about double the height. Each bundle is tied and upper portion of rachis is wrapped in either tissue or grease paper. The bundles should be placed in two parallel rows, two in one row and other two in second rows. The direction of rachis in two rows should be in opposite direction. Paper is to be placed below the bundles and in between bundles and then transported to distant places.

Yield: The yield in tuberose crop varies with the type of cultivar, size of bulb, time of planting, density of planting and other management practice adopted. Normally 2 lac to 4 lac spikes/ha or 10-15 tonnes loose flower/ha can be obtained. Yield of bulbs varies from 18-30 tonnes/ha.

CHAPTE5(iii)Marigold

Introduction: Extensively used for making garlands, beautification and other purposes i.e. pigment and oil extraction, insect and nematode repellent. It belongs to family Asteraceae and is originated from Mexico and south America.

Varieties: Alaska, Apricot, Burpee's Giant Fluffy, Burpee's Miracle, Burpee's White, Chrysanthemum Charm, Crackers Jack, Crown of Gold, Cupid Double Eagle, Doublebloom, Golden Yellow, Goldsmith, Guinea Gold, Happiness, Happy Face, Hawaii, Honeycomb, Orangemum, Pusa Narangi Gainda, Pusa Basanti Gainda, Primerose, River Side, Sovereign, Snowbird, Sugar and Spice, Sun Giants, Super Chief Double, Sutton's Giant Orange Double, Yellow Climax, Yellow Fluffy and Yellowstone.

Climate: They require mild climate for proper plant growth and profuse flowering. Its ceases growth at high temperature, thereby flower quantity and quality are adversely affected. In general, marigold need plenty sunshine and are grown in open sunny situation in India. The critical photoperiod for *T. erecta* is below 12.5 and 13 hours and failed to grow under short days at higher temperature.

Soil: Marigold can be grown in a fertile, deep, friable soil with good water holding capacity is required for luxuriant plant growth and profuse flowering. It should also be well drained and well aerated with pH 5.8-6.2.

Propagation: Commonly marigold is propagated by seeds and cuttings. Seed propagation is widely adopted because plants raised from seeds are vigorous and yield more due to good establishment in the field than cuttings.

Cultural operations

Weed control: Generally 3-4 weedings are required for entire growth period. Chemical weed control has been found beneficial. For French marigold, granular formulations of simazine 2.0 kg a.i./ha, and EPTC and chloramben at 5.0 kg a.i./ha applied as post plant application was reported to be effective in controlling weeds.

Pinching: Marigold plants grow straight upwards to their final height and develop into terminal flower buds. Single pinching at 40 days after transplanting was found effective at Ludhiana. In high density planting (15×15 cm), double pinching i.e. at 40 and 60 days after transplanting have been recommended for higher flower and seed yield.

Manure and fertilizers: It is advisable to apply 200 kg/ha of nitrogen and 80 kg/ha each of phosphorus and potash for good flower yield. Full dose of phosphorus and potash should be incorporated in the soil during land preparation, whereas quantity of nitrogen should be applied in two split doses after 30 and 60 days of transplanting. It is better if two foliar spray of 0.20 per cent urea are done at an interval of 15 days.

Diseases

Fungal: Damping off, Collar rot, Leaf spot, Botrytis flower blight, Fusarium wilt and Septoria leaf spot

Bacterial: Bacterial leaf spot

Insect pests: Red spider mite, Leaf hopper and Hairy caterpillar

Physiological disorders

Leaf burn: Tips and margins of leaves yellow and die due to excess boron, manganese or molybdenum. Application of micronutrients should be done carefully after soil analysis.

Mn, Mo and B should not be more than 55 ppm, 24 ppm and 3 ppm, respectively.

HARVESTING: Marigold flowers should be plucked when they attain full size. Plucking of flowers should be done in cool hours of the day. Irrigation of field is found beneficial to keep flower fresh, after harvesting and can be transported to long distance.

Postharvest management: After harvesting, flowers should be kept in small or big baskets. **Grading and packaging:** Flowers are generally packed in gunny bags for transportation to the local market. Precaution should be taken to packing of flowers for long distance. For this purpose, medium size baskets should be taken. Bamboo baskets should be covered with gunny and moistened before transportation.

Yield: In general, a yield of 20-22 tonnes of fresh flowers can be obtained from one hectare of plantation in case of African marigold, whereas from French marigold it is 12-15 tonnes per hectare under normal cultivation practices.

CHAPTE5(iv)Jasmine

Introduction: Jasmine is a sweet-scented plant grown both as shrub and climber. Flowers and flower buds are used for making garlands, bouquets and Veni and for religious offerings. Jasmine oil extracted from the flower is highly valued as it is used in manufacturing perfumes, cosmetics, creams, hair oils, soaps and shampoos. Jasmines are native of tropical and sub-tropical regions and belongs to family Oleaceae.

Varieties: *Jasminum auriculatum* Vohl

Parimullai: A clonal selection from germplasm. Buds are white. Corolla tube is moderate.

Flower yield is 7.8 t/ha and concrete recovery is 0.29%.

CO-1: This is a local selection from a local type. Buds are white and bold with long corolla tubes. Concrete recovery is 0.34%.

CO-2: A clonal selection from germplasm. Buds are white with longer corolla tube than CO-

1. Different variants identified basically on the flower characters are Long Point, Long Round, Medium Point, Short Point, Short Round and Big Mullai.

***Jasminum grandiflorum* (Linn.) Kobuski:** CO-1, CO-2, Arka Surabhi,

***Jasminum sambac* Ait:** Double Mogra, Gundumali, Iruvatchi, Kasthurimalli, Madanban,

Oosimalli, Ramabanam, Single Mogra, Soojimalli, Khoya and Arka Aradhana

Climate: In general, mild tropical climate is good for proper plant growth and flower production. In India jasmines are grown under open field conditions. Hence, for successful cultivation mild winter, warm summer, moderate rainfall and sunny situations are required.

Soil: Jasmine gives good result in well-drained rich loam soil. Water logging conditions damages plants of jasmine. Soil pH vary from 5-8.

Propagation : Jasmine can be propagated by seed propagation or vegetative means i.e. cutting, layering, budding and grafting. Seed propagation, though uncommon, is necessary for crop improvement through hybridization. Multiplication through sucker in *J. arborescens* and *J. multiflorum* has also been found successful.

Cultural operations

Weed control: Manual weed control is effective if done properly but chemical weed control (Paraquat and glyphosate at 2.0 kg a.i./ha) is economical.

Pruning: Pruning influences plant growth, flower bud initiation and differentiation and ultimately resulted in more flower production. Among the various dates of pruning from third week of January to third week of March at Coimbatore, maximum flower yield was observed in third week of January in *J. auriculatum*. In *J. sambac* maximum flower yield was recorded by pruning on last week of October.

Chemical defoliants: Various chemical defoliants reduced the apical dominance and encourage lateral shoots. Application of 3000 ppm of pentachlorophenol was found more effective in flower production than potassiumiodide,boll'seye,ethrel and paraquatdichloride in *J.grandiflorum*.

Manure and fertilizers: For higher yield, a fertilizer dose of 120 g N, 240 g P and 240g K/plant proved to be the best in *J. auriculatum* under Coimbatore conditions. In *J. sambac*, a basal dose of FYM (10 kg/plant) and N, P, K, Fe, and Zn at 60,120,120,25 and 4 g/plant in two split doses (December and June) is recommended for higher flower yield under Coimbatore conditions. Biofertilizers i.e. Azospirillum and phosphobacteria along with 75% of recommended nitrogen and phosphorus doses resulted in maximum flower yields in *J. sambac* cv Gundumalli and *J. grandiflorum* cv CO-2 at Coimbatore.

Diseases

Fungal: Leaf blight, Rust and Wilt.

Viral: Mosaic and Phyllody.

Insect pests: Bud worm, gallery worm, tingid bug and scales, Mites, Hopper, bug, leaf roller and blossom midge, scales and nematodes.

Harvesting: Flowering in jasmines starts from second year or some earlier, but economic yield is generally obtained from third year. The stage of flower harvest depends upon the purpose of use. For fresh flower fully developed unopened flower buds are picked early in morning, while for extraction of concrete only fully opened freshly picked flower are required which are picked early in the morning. Delay in picking result in gradual reduction of concrete yield. Care should be taken that flowers are not badly handled and should not be wrinkled and damaged during harvesting. For concrete extraction, fully open flowers are harvested in the morning (6 to 8 am). In India jasmine flower are harvested manually. In other countries for harvesting purposes suction harvester is used.

Grading and packaging: Flower bud should be graded according to corolla shape, size and freshness before packing in the boxes or baskets for marketing. Corrugated cardboard boxes are proper packing material for distant market while bamboo basket may be used for local market. Harvested flower should be given cold treatment before packing. Flowers are packed so as to maintain some moisture and air circulation in the basket. Water is sprinkled on the newspaper covering the inside of the basket.

Yield: Flower and concrete yield in Jasmines varies considerably according to

the species, cultivars and management practices etc.

Species	Flower yield	Concrete recovery (kg/ha)
<i>Jasminum auriculatum</i>	4636 to 9022 kg/ha	0.28 to 0.36% (13.44-28.24)
<i>Jasminum grandiflorum</i>	4239 to 10,144 kg/ha	0.25 to 0.32% (13.85-29.42)
<i>Jasminum sambac</i>	2063 to 8129 kg/ha	0.14 to 0.19% (11.18-15.44)

CHAPTER5(v)**Chrysanthemum**

Introduction: It is commonly known as Queen of East, Autumn Queen and Guldaudi. It is used as a potted plant, loose flower, cut flower and as border plant in the garden. Chrysanthemum cinerariifolium yield pyrethrin insecticides. It belongs to family Asteraceae and are natives of China, Japan, North Africa and southern Europe.

Classification

Large flowered group or Standard form

Incurred: Ray florets are incurred and flower is compact and globular. Eg.

Snowball and Chandrama

Reflexed: Ray florets are reflexed outside and bloom is flat. Eg. Sweet Heart and day Dream.

Intermediate: Inner florets are incurred and outer florets are reflexed type. Eg. Sun Flight.

Quilled: Ray florets are elongated and tubular. Eg. Tribhuvan and Green Sensation.

Spider: Ray florets are large, tubular and curved like a spider. Eg. Mahatma Gandhi, Rupasi Bangla.

Ball: Ray florets are radiated in all direction like a ball. Eg. Nigeria and Red Jack.

Irregular: blooms are with irregular overlapping petals. Eg. Mountaineer.

Small flowered group or spray form

Korean Single: Blooms are flat with 5 or less than 5 whorls. Eg. Cardinal, Gul-e-Sahir.

Korean Double: Blooms are flat with more than 5 whorls. Eg. Flirt, Man Bhawan. **Decorative:** flowe is completely double and disc florets completely invisible. Eg. Blue Chip, Alankar.

Anemone: Blooms with flat ray florets and prominent and well developed disc florets. Eg. Baggi, White Bouquet.

Button: Small compact hemi-sphareical blooms like buttons are present. Eg. King Fisher, Gold Dust.

Quilled: Florets are fully tubular. Eg. Snow Crystal, Yellow Hector.

Semi-quilled: Florets are tubular upto some length and then are opened. Eg. Golden Crystal. **Cineraria:** Flowers very small (less than 3 cm) and flat, perfect for pot culture. Eg. Bindya, Charmis.

Stellate: these are star like flowers with very short disc florets. Eg. Stella, Red Star.

No Stake and No Pinching: Very compact plant which requires no staking and no pinching. Eg. Appu and Sharad Kumar.

Varieties: Some popular released varieties from different institutes are National Botanical Research Institute, Lucknow: Apsara, Arun Singar, Birbal Sahani, Haldighati, Hemant Singar, Kargil'99, Sadbhavana, Shanti, Sharad Singar and Y2K. Indian Institute of Horticultural Research, Bangalore: Kirti, Pankaj, Rakhee, Ravikiran and Red Gold.

Punjab Agricultural University: Punjab Gold

Annual chrysanthemum: Primrose Gem, Whity, Flame Shades and John Bright.

Large flowered:

White: Snow Ball, Kasturba Gandhi, Beauty and Innocence.

Yellow: Chandrama, Sonar Bangla, Super Giant, Mountaineer, and Evening Star.

Mauve: Mahatma Gandhi, Peacock, Pink Turner, Classic Beauty and Pink Giant.

Red: Diamond Jubilee, Distinction, Alfred Wilson and Autumn Blaze.

Small flowered varieties suited for pot culture:

White: Sharad Shoba, Shweta Singar, Rita and Niharika.

Mauve: Sharad Prabha, Hemant Singar and Fantasy.

Yellow: Indira, Sonali Tara and Sharad Kanti.

Red: Rakhee, Flirt, Jaya and Arun Singar.

Small flowered varieties suitable for cut flowers:

White: Birbal Sahani, Apsara and

Himani. **Yellow:** Nanako, Jayanti and Kundan.

Mauve: Sharad Prabha, Nilima and Ajay.

Red: Jaya, Flirt and Jubilee.

No pinch cultivars: Arun Singar, Rangoli, Haldighati, Suhag Singar, Bindiya, Mother Teresa and Dina.

Climate: The critical day length is 14-15 hours for flower initiation and 13-14 hours for flower development. The best temperature for growing chrysanthemum ranges from 20-28°C for day and 15-20°C for night. Chrysanthemum requires 70-90% relative humidity.

Soil: It requires sandy loam with a pH of 6.2 to 6.7, having good tilth with proper aeration and drainage facility. EC should be 1.0 to 1.5.

Propagation : Chrysanthemum is vegetatively propagated through suckers, cuttings and by micropropagation.

Suckers: Optimum time of separation is, when 5 to 6 green leaves appear. Basal leaves and long roots should be cut before planting.

Terminal cuttings: Cuttings of 5-7 cm length are taken from healthy, disease free stock plants by shearing basal leaves and cutting half of the open leaves. Dipping of basal portion of cuttings in IBA 2500 ppm improves rooting percentage.

Micropropagation: Protocols have been developed by various workers and success has been reported in multiplying chrysanthemum at a faster rate by using shoot apex, peduncle, leaves and other floral parts as explants.

Seed: Treatment of thiourea promotes germination of dormant seeds. Seedlings are transplanted 30 days after seed sowing.

Cultural Operations:

Weed control: Regular hand weeding in early stages should be done. Herbicides like alachlor, oxadizon and oxyfluorfen are also found effective in this crop.

Pinching: Pinching can be performed both in suckers and cuttings. Generally two pinching are required in chrysanthemum plants first at 4 weeks after planting and second at 7 weeks after planting. In spray chrysanthemum regular pinching is done to produce maximum number of flowers per stem. Generally three types of pinching is performed in chrysanthemum, as given below.

Soft pinching: This is done to reduce plant height by removing tips of branches. Shoot along with 2-3 open leaves are kept in initial stages.

Hard pinching: It is done in pot plants. It removes a longer plant portion to keep the plant compact.

Roll out pinching: It is practiced only in short plants.

Disbudding: Disbudding is done to remove the side branches and to control flower number and size. It is usually done in large flowering and Decorative cultivars.

De shooting: It is practiced to reduce number of branches, for improving the size and form of the flower.

Mulching: Mulching discourages weeds and conserves moisture for good growth of root system. Buckwheat hulls, ground corncobs, pine needles, straw,cottonseedsetc.aretthecommonmulchesusedinthechrysanthemum.

De suckering: For preventing improper and vigorous growth of plant, suckers are removed from time to time. Without de suckering, the plant will loose vigour and becomes weak. **Manure and fertilizers:** Nitrogen 50 kg, phosphorus 160 kg and potassium 80 kg should be provided as basal dose.

Diseases

Fungal: Leaf spot, powdery mildew and flower rot.

Black spot is a serious disease of chrysanthemum caused by *Septoria chrysanthemella* fungus. Grey circular spots appear on leaves which turn yellow and results in leaf fall. Spray of 0.2% Dithane M 45 prevents this disease.

Powdery mildew in chrysanthemum is caused by *Oidium chrysanthemi* fungus. Symptoms, effect and control are same as in rose powderymildew.

Flower rot is caused by *Botrytis cinerea* fungus leading to the appearance of water soaked brown spots on flower petals and flower rot. This disease can be controlled by spray of 0.2% Dithane M 45.

Viral: Chrysanthemum is affected by a number of viral diseases. The flowers of virus infected plants are reduced in size and show varying amounts of distortion and loss of colour. For controlling the spread of viruses, infected plants should be destroyed, vectors like aphids and thrips should be controlled by regular spraying of rogor (0.15%).

Insect pests: Aphids, Hairy caterpillars, Red Spider mite, Thrips and Nematodes.

Harvesting: Standard chrysanthemums are harvested when fully open but before central disc begin to elongate. Spray cultivars are harvested when fully open but before shedding of pollens and pompons are harvested when centre of oldest flower is fully open.

Grading and packaging: Most of the Standard chrysanthemum are placed in poly sleeves and packed in display boxes measuring 91 cm x 43 cm x 15cm. They are placed in the boxes according to the grade. Flowers are generally packed in bamboo basket and polythene bags. Packing in 200 gauge polythene bag enhances freshness, colour and longevity. Loose flowers can be stored at 3-5 °C for two weeks at higher humidity and proper ventilation.

Yield: In standard type of chrysanthemum, yield of flower stems varies from 15-20. The yield of loose flowers range from 10-15 tonnes flower/ha.

CHAPTER6(iii)**Production technology of Aloe**

Botanical name: Aloe vera and Aloe barbadensis

Family: Liliaceae

Origin: Indigenous to Eastern and Southern Africa

Distribution: The genus Aloe is widespread throughout the entire African continent, but the tropical regions are particularly rich. It is also grown as an ornamental in India. Aloe vera is cultivated in fairly large areas many parts of India viz. Chhattisgarh, Maharashtra, MP, and Gujarat.

Plant part: Leaves, seeds, roots

Major constituent: Anthraquinone glycosides Barbaloin

Description of the plant: Aloe is a coarse looking, perennial, shallow rooted plant with a short stem, 30-60 cm high. The plants have multiple tuberous roots and many supporting roots penetrating into the soil. Aloe does not have a true stem but produces bloom stalks. The fleshy leaves are densely crowded, strongly, cuticularized and have a spiny margin with thin walled tubular cells. The flowers vary from yellow to rich orange in colour and are arranged in axillary spikes. The ovary is superior, triocular with axile placentation. The plant does not produce many viable seeds.

Importance and uses:

Two of the major products derived from the leaves are the yellow bitter juice consisting of aloin and the gel consisting of polysaccharides.

Apart from these products, several other products like dehydrated aloe powder, concentrates are also prepared.

Aloe also having anthro glycosides – Barbaloin – 4.5 to 25% and aloin.

It is used for medicinal preparation and for flavouring liquors and a source of the drug ‘aloe’.

These are extensively used as active ingredients in laxative and anti-obesity preparation, as moisturizer, emollient or wound healer in various cosmetic and pharmaceutical formulations.

Aloe gel contains gluco mannan which is a polysaccharide similar to guar used in preparations of burn, first aid medicines.

Aloe and aloin are extensively used as active ingredients in laxative preparations.

Extracts of aloe or aloin are used in sunscreens, X-ray / burns, dermatitis and other cosmetic preparations.

It is reputed remedy for intestinal worm in children.

It is used in haemophilia, skin, liver disorder, constipation and rectal fissures piles. Varieties: Aloe vera var chinensis is commonly cultivated

Soil: Hardy and grown on variety of soils, does well in sandy coastal and loamy soils with pH up to 8.5. Water logged and problem soils not suitable

Climate: Wide adaptability, hence cultivation is possible throughout the country and prefers warm humid dry climate with 150-200 cm to 35-40 cm yearly rainfall.

Propagation: Root suckers or rhizome cuttings

Land preparation: The field should be prepared well before the onset of monsoon and small furrows opened.

Planting: 15-18 cm long root suckers, rhizome cuttings are planted with a spacing of 60 x 30 cm or 60 x 45 cm and buried 2/3 portion under the ground.

Fertilizer: Application of a mixture of 150kg/ha of nitrogen, potassium and phosphorus is recommended. The fertilizers are applied in the soil near the root system, after the plants are established.

Irrigation: Immediately after planting needs one irrigation and totally 4 to 5 irrigations / year required.

Interculture: The land is kept weed free by weeding the plot as and when necessary.

Pests and diseases:

Pest:

Mealy bug- For controlling mealy bugs sprays Chlorpyrifos 2 ml in 1 litre of water. Diseases: Leaf spot, Leaf rot and Anthracnose

Leaf spot: Leaf spot can be controlled by spraying the crop with 0.2% Mancozeb at weekly intervals.

Leaf rot and Anthracnose: Spray the crop with Bavistin 10 g with Carbendazim 2g per litre and repeat at 10 days interval for controlling leaf rot and anthracnose.

Harvesting: Plants should be removed by manually or with tractor after eight months of planting. Commercial yield starts from second year to up to five years.

Yield: Fresh weight 10000 – 12000 kg/ha.

CHAPTER6(vi)

Production technology of Periwinkle

Botanical name: *Catharanthus roseus*

Family: Apocynaceae

Plant parts used: Leaves, seeds, roots

Major constituent: Ajmalicine (raubasin)

Origin and Distribution: The plant is a native of Madagascar and from there it has spread to India, Indonesia, Indo-China, Philippines, South Africa, Israel, USA and other parts of the world. In India, it is being grown in Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh, Gujarat and Assam.

Importance:

It has medicinal importance owing to the presence of alkaloids like ajmalicine (raubasin), serpentine and reserpine in roots, which is well known for their hypotensive and antispasmodic properties.

It gained importance after the isolation of vincristine and vinblastine alkaloids from leaves, which have importance in cancer therapy.

Vincristine sulphate is being marketed under the trade name ONCOVIN,

which is used against acute leukemia and vinblastine sulphate as VELBE to cure Hodgkin's disease.

Farmers prefer it because of its wide adaptability and its ability to grow in marginal lands and its drought tolerance.

Periwinkle is a perennial ornamental herb found throughout India on waste lands and sandy tracts.

It has medicinal importance owing to the presence of indole alkaloids raubasin (ajmalicine) and serpentine in its root which has hypertensive properties.

The leaves contain two alkaloids viz., Vinblastine and Vincristine which form the constituents of patented cancer drugs and vincristine alkaloids are distributed in different parts of the plant but the roots contain the maximum (0.75 t to 1.20%) followed by the leaf (0.60 to 0.65%).

USA is the world's largest user of this plant's raw material. A single firm which has the patent to manufacture Vinblastine and Vincristine sulphate have been consuming more than 100 t of leaves of the plant annually.

Description of plant: It is a perennial herb which grows up to 90-120 cm tall. It is a diploid with the chromosome number $2n = 16$.

Varieties: There are no recognized varieties but there are three local types based on the colour of the flowers viz., alba with white flowers, roseus with pink rose coloured flowers and ocillata with white flowers having rose purple spot in the center are recognized. The first type is being cultivated because of its higher alkaloid content. Recently, two white flowered varieties named "Nirmal" and "Dhawal" have been released by the CIMAP,Lucknow.

Climate: The distribution of the plant shows that there is no specificity in its climatic requirements. It comes up well in tropical and subtropical areas. However, the growth in tropical areas is better than in the subtropical areas, where its growth is slow due to the low temperatures in winter. It can be successfully grown up to an elevation of 1300 m above sea level. A well distributed rainfall of 100 cm or more is ideal for raising this crop on a commercial scale under rainfed conditions.

Soil: The crop is quite hardy and grows well on a wide variety of soils, except those which are alkaline or water-logged. Deep sandy loam to loam soils of medium fertility are preferred for its large-scale cultivation. Because, in this soil there is not only a better development of roots, but it is also easy to take them out at harvest time.

Propagation: The plant is propagated from seeds. Fresh seeds are preferable as they lose viability on long storage. Seeds can be sown directly in the field or the plants raised in the nursery and transplanted later on. Direct sowing is to be done for plantations of a large area, as it reduces the cost of sowing. About 2 to 3 kg seed are required for raising one hectare. The seeds are mixed with sand about 10 times its weight for even distribution and are sown during beginning of monsoon in rows 45 cm apart. When the plants grow up they are thinned out leaving a distance of 25 to 30 cm between the plants.

For nursery sowing and transplanting, about 500 grams of seed sown in 200 square meters bed is required for producing seedlings for one hectare. The seeds are sown in well prepared beds during March or April in rows about 1.5 cm deep, covered with light soil and leaf mould mixture and are watered to keep the bed moist. In about 10 days time the seeds germinate in 2 months time (height 6-7 cm) they become ready for transplanting. In the field, the seedlings are transplanted at a spacing of 45 cm x 30 cm or 45 cm x 45 cm.

Weeding: The crop requires two weeding, the first one about 60 days after sowing or transplanting and the second one in another 60 days.

Irrigation: The plant does not require much water as they have drought resistant capacity. In areas, where rainfall is evenly distributed throughout the year, no irrigation is required, but in areas where monsoon is restricted, 4 to 5 irrigations are required during the life of the plant to get good yield.

Manures and fertilizers: FYM is applied at the rate of 10 – 15 t/ha to obtain good growth and yield. If irrigation is available, green manure crops can be raised and ploughed into the field at the time of flowering. In case organic manure is not applied it is advisable to apply a basal dose of 20 kg N, 30 kg P₂O₅ and 30 kg of K₂O per hectare per year. In addition, a top dressing with 20 kg nitrogen can be given in two equal split doses during the season.

Pests and diseases: Plant is hardy hence devoid of pest and diseases.

Occasionally they suffer from little leaf due to infection by mycoplasma resulting in stunted growth. This can be effectively checked by uprooting and destroying the affected plants.

Die back / Twig blight/top rot is reported during monsoon. Control measure is spraying Mancozeb at an interval of 10 -15 days.

Harvesting:

Harvesting for leaves: Leaf stripping twice, first after 6 months and the second after 9 months of sowing can be taken. A third leaf stripping is also obtained when the whole plant is harvested. After the plant is harvested, it is dried in the shade.

Harvesting for roots: The crop is harvested one year after planting. The plants are cut about 7.5 cm above the ground level and dried for the stem, leaves and seeds. The field is then copiously irrigated and when it reaches proper condition for digging, it is ploughed and the roots are collected. The roots are washed well and dried in the shade.

Harvesting for seeds: For seed collection, matured pods are picked after 9 months of planting or before 2-3 months of the whole plant harvest and threshed lightly.

The total alkaloid content in the leaf varies from 0.15 to 1.34%, of which the average content of vinblastine is 0.002%, while that of vincristine is 0.005%.

Yield: Under irrigated conditions, about 4t/ha of leaves, 1.5t/ha of stem and 1.5t/ha of roots, on air dried basis may be obtained. Whereas, under rainfed conditions, the yield will be about

2 t/ha of leaves and 0.75t/ha each of stem and roots on air dried basis. The total alkaloid content in the leaf varies from 0.15 to 1.34 % of which the average content of Vinblastine is 0.002% while that of Vincristine is 0.005%

CHAPTER6(vii) Production technology of Isabgol(Plantago)

Botanical name: Plantago ovata

Family: Plantaginaceae

Origin: Indigenous

Distribution: It is indigenous to the Persia and West Asia, extending upto the Sutlej, Sind and West Pakistan. Isabgol crop has acquired the place of the 'dollar earner' crop of north Gujarat. Southern Rajasthan, Punjab, Maharashtra and UP states are also grown isabgol crop.

Plant parts used: Seeds and husks

Major constituent: Xylose, arabinose and galacturonic acid

Description of the plant: It is a 30-40 cm tall stem less or short stemmed annual herb. Leaves are born alternately on the stem. Flowers in terminal spikes; fruit is a capsule. The flowers are white and minute. Highly self-pollinated. The capsule is ovate, 8mm long, releasing the smooth, dull, ovate seeds which are translucent and convex. The seeds are covered with a translucent membrane, known as the husk. The husked seeds are dark red and hard.

Importance and uses:

Isabgol is important for its seeds and husks which have been used in indigenous medicine for many centuries.

It derives its name from two Persian words, ‘asp’ and ‘ghol’ meaning a ‘horse ear’ referring to its characteristic boat-shaped seeds.

The husk of the seed is economic part and it contains colloidal mucilage mainly consisting of xylose, arabinose, galacturonic acid.

It has the property of absorbing and retaining water (40-90%) and therefore it works as an anti-diarrhoea drug.

It is beneficial in chronic dysenteries of amoebic and bacillary origin.

The seed has also cooling and demulcent effect and is used in ayurvedic, unani and allopathic medicines.

It is also used for treating constipation and intestinal disorders as it works as calorie free fiber food, promoting regular bowel movement.

Varieties: Gujarat Isabgol-1 and Gujarat Isabgol -2 are the two varieties of this crop released by Gujarat Agricultural University which have a yield potential of 800 – 900 kg and 1000 kg

per ha respectively. Another variety, 'Niharika', a mutant has been released by the CIMAP, Lucknow, as a high yielding variety.

Climate It requires cool and dry weather and hence in India, the crop is grown in winter i.e. from November – December to March-April. Humid weather at maturity results in shattering of seeds. The temperature requirement for maximum seed germination is reported to be 20 to 30°C.

Soil: A light well drained sandy loam to rich loamy soil with a pH of 4.7 to 7.7 with high nitrogen and low moisture content is ideal for growth of plants and high yield of seeds.

Preparation of land: Field must be free of weeds and clods and should have fine tilth for good germination. The land is laid into flat beds of convenient size i.e. 1.0 m x 3.0 m or 2.5 m x 2.5 m

Land preparation: Field must be free of weeds and clods. The number of ploughing, harrowing and hoeing depends upon the soil conditions, previous crop and degree of weed infestation. The recommended dose of FYM (10-15t/ha) is applied to the field at the time of last ploughing. The field should be divided into suitable plots of convenient size (i.e. 1.0 m x 3.0 m or 2.5 m x 2.5 m), depending upon the texture of the soil, the slope of the field and quantum of irrigation.

Seed sowing: To obtain high percentage of germination, seed should be taken from the crop harvested at the end of the preceding crop season. Old seeds tend to lose viability under ordinary storage conditions. Seed at the rate of 4-8 kg per hectare is sown after with thiram@3g per kg of seed to protect the seedlings from the possible damage of damping off. The seeds are small and light. Hence before sowing, the seed is mixed with sufficient quantity of fine sand or sieved farmyard manure. The seeds are sown broadcast and are swept lightly with a broom in one direction to cover them with some soil. The sowing should immediately be followed by irrigation. Germination begins in four days after sowing. If delayed, it should be stimulated by another watering.

Manures and fertilizers: The FYM of 10-15 tonnes /ha is applied during land preparation. Isabgol does not require application of heavy doses of fertilizers. A fertilizer dose consisting of 50kg N, 25kg P₂O₅ and 30kg K₂O/ha gives maximum seed yield. The full dose of P and K along with half of the N is given as a basal dose. The second split of N is applied as a top dressing after one month of sowing.

Irrigation

Immediately after sowing, light irrigation is essential. First irrigation should be given with light flow or shower of water otherwise, with fast current of water most of the seeds will be swept to one side of the plot and the germination and distribution will not be uniform. The seeds germinate in 6-7 days. If the germination is poor, second irrigation should be given. Later on irrigations are given as and when required. Last irrigation should be given at the time when maximum number of spikes shoots up (milk stage). The crop requires totally 6-7 irrigations for its good productivity in medium sandy soils.

Interculture: Periodical weeding and hoeing is required. After 20-25 days of sowing, first weeding is done and 2-3 weedings are required within 2 months of sowing.

Pests and diseases:

Pests: White grubs and termites damage the crop by cutting off the root which can be controlled by broad casting phorate 10G @10kg/ha. Aphids also attack the crop and can be controlled by spraying 0.2% Dimethoate.

Disease: Downy mildew is the major disease caused by Peronospora plantaginis. The disease appears at the time of spike initiation. The first symptom is small patches on the leaves, completely destroying it and thus affecting the yield. To control it, Bordeaux mixture or Dithane M-45 or any copper fungicide at the rate of 2-2.5g/l can be sprayed.

Harvesting and processing: Blooming begins two months after sowing and the crop become ready for harvest in February-March (110-130 days after sowing). When mature, the crop turns yellowish and the spikes turn brownish. The seeds are shed when the spikes are pressed even slightly. At the time of harvest, the atmosphere must be dry and there should be no moisture on the plant, harvesting will lead to considerable seed shattering. Hence, the crop should be harvested after 10 am only. After two days, they are threshed with the help of tractor during early morning. Water is sprinkled over the heap for easy thrashing and separation. The husk: seed ratio is 25:75 by weight.

Yield: The average yield is 800-1000 kg of seeds per hectare.

CHAPTER7(i)**ProductiontechnologyofMint****Production technology of Mint**

LocalName : Pudina

BotanicalName:Mentha sp.

Family : Labiateae(Lamiaceae)

Origin : Japanese mint originated from Brazil and China

Major constituent:Menthol

Speciesofmint:Fourmostcommonlycultivatedspeciesare:

JapaneseMint/MentholMint : *Mentha arvensis*

Peppermint : *Mentha piperita*

Spearmint : *Mentha spicata*

Bergamotmint : *Mentha citrata*

Japanese mint is most widely grown commercially crop of India. This is mostly grown in Jammu, UP, and Punjab in India.

Oil content: 0.5 to 0.68 %

Varieties: Japanese mint- Himalaya (MAS-1), Kalka (Hybrid-77), Shivalik, EC-41911, Gomati, Koshi, Saksham and Kushal

Propagation: Mint can be propagated vegetatively through stolons and runners.

Climate: Normally tropical climate is not suitable for mint cultivation. While,

Japanese mint can be cultivated both in tropical and sub-tropical areas. The mean temperature between 20-40⁰ C during major part of the growing period and rainfall between 100-110 cm. (light showers at planting stage and ample sunshine at the time of harvesting) is ideal for its cultivation.

Soils: Well drained loam or sandy loam soils rich in organic matter having pH between 6 and 8.2 are ideally suited for its cultivation. It can also be cultivated on both red and black soil. Clay soils are not suitable.

Land preparation: Bring the soil to fine tilth by ploughing and 2 cross harrowing. Add well decomposed FYM @ 30-40 ton per hectare while preparing the land.

Planting Season: In northern India, planting of Japanese mint is suitable from first week of February to second week of March or before the start of rainy season

Planting: The field should be divided into beds of suitable size to facilitate irrigation and make it free from weeds and stubbles. Cut the stolons/ runners into 10-12 cm length before sowing. Stolons/ runners should be set in furrows 5-6 cm deep with a spacing of 60-75. Plant the suckers end to end. Plants should be spaced 30 cm apart in rows 60 cm apart. The bed is irrigated immediately after placing the stolons. On an average, 4-5 quintals of stolons are required for planting in one hectare of land. The stolons sprout in about 2 to 3 weeks when planted in February.

Inter-culture: In mint plantation, after planting four to fourteen weeks are very crucial for weed control. In order to keep the top soil loose for better penetration of water, air, sun light and weed free.

Irrigation: Mentha crop requires considerable moisture well distributed throughout the entire growing season. As roots do not penetrate deep in the soil, light and frequent irrigations are recommended. During summer 10-12 irrigation required for menthe.

Fertilizers: FYM at the rate of 20-25 tonnes per hectare is recommended and this organic manure gives good response. At the time of planting 50 kg N + 75 kg P₂O₅ + 37 kg K₂O per hectare is given as basal dose and 75 kg of N per hectare as top dressing in three equal doses should be applied. First top dressing is when the plants are about 15 cm high and the remaining doses of nitrogen should be applied after each harvest.

Plant Protection Measures:

Insect Pests

Hairy Caterpillar- The caterpillar starts eating the under-surface of the leaves.

Control- Application of Thiodan or Malathion @1.7ml/ litre of water

Cutworms- Young plants are damaged at the collar region during spring season.

Control- Soil treatment with Phorate 10 g before planting.

Mint Leaf Roller- The caterpillar folds the leaf in the form of a roll and feeds inside the leaf tissue during August-September. The edges of the leaves are held together with silk-like filaments.

Control- Two to three sprayings of Thiodan @1.5ml/litre of water at weekly intervals.

Diseases

Stolon Rot- During rainy season, stolon rot occurs on the underground parts; the infected stolons show brown lesions which enlarge and turn black, resulting in a soft decay.

Control- Crop rotation. It is better to follow 3 year crop rotation with rice, wheat and mint. Treatment of the stolons with 0.25% solution of Captan or 0.1% Benlate, 0.3 % Agallool solution for 2 to 3 minutes before planting is a preventive measure. Leaf blight- Cause loss of foliage during summer season.
Control- Application of copper fungicide.

Harvesting: First harvesting commences about 4 months after planting. Crop harvested in sunshine at a height of 4 to 8 cm from the ground level.

Normally 2-3 times in a year

1. First crop should be harvested before the onset on monsoon(May-June).
2. Second harvesting well after monsoon is over (September -October).
3. Third harvesting (November -December)

Yield: The average yield is 20 tonnes of fresh herbage per ha in two harvests, which, in turn, yields around 25 kg of oil in a year.

Oil extraction: Steam distillation is good for extraction of menthe oil. The herbage should be allowed to wither for 12-24 hours before distillation.

Varieties of Pepper mint: Kukrail, Pranjali, CIM Madhuras, Cim Indus and Tushar

Varieties of Spear mint: Punjab Spearmint-1 (released from Y.S, Parmar University of Horticulture), Arka and Neera (released from CIMAP) and Neer Kalka

CHAPTER7(ii)**Production technology of Lemongrass**

Botanical Name- *Cymbopogon flexuosus*

Family- Poaceae

Origin- India

Distribution- Tropical and sub-tropical parts of Asia, Africa and America

Major constituent: Citral, Citronella, Geraniol

Sr. No.	Common Name	Botanical Name	Oil per cent
1	East Indian lemongrass	<i>Cymbopogon flexuosus</i>	1.0-1.2 %
2	West Indian lemon grass	<i>Cymbopogon citratus</i>	1.0%
3	Jammu and north Indian lemongrass	<i>Cymbopogon pendulus</i>	0.75%

Varieties:

The following varieties are recommended for commercial cultivation:

- (i) Sugandhi(OD-14)-Release from the Aromatic and medicinal plants Research station(AMPRS) Odakkali, Kerala
- (ii) Pragati- From CIMAP,Luckow
- (iii) RRL-16

(iv) C.K.P-25: Released by RRL, Jammu for irrigated condition

(v) Krishna: Developed by CIMAP both for irrigated and rainfed and also hillslopes

(vi) Nima: A dwarf variety developed by CIMAP found promising. The citral content of Nima is much higher than Krishna. Oil recovery is in between 0.8-1.0%.

Climate: The plants are hardy and grow under a variety of conditions. The most ideal conditions are a warm and humid climate with, plenty of sunshine and rainfall of 250-280 cm per annum, uniformly distributed.

Soil: It can be grown in poor soils, in the hill slopes. Soil pH ranging from 4.5 to 7.5 is ideal. As it has good soil binding nature, they can be grown as vegetative cover over naked, eroded slopes.

Propagation- seeds, Vegetative and rooted Slips

Nursery Raising- For raising the seedling, 1000 m² area is required for 1 ha planting. The recommended seed rate is 3-4 kg/ha. Seeds are sown in the nursery during April-May. For raising the crop by direct seeding, a seed rate of 25 kg/ha is recommended.

Planting- Planting is done in May-June. However, with irrigation planting can be done during any month of the year except December-January. One or two slips are planted into each hole, about 5-8 cm deep.

Spacing- 30x30 or 60 x 45 cm for seedlings and 90x60 cm for slips have been recommended for fertile, irrigated land.

Manures and fertilizer:

FYM: 10t/ha to be applied and mixed well at the time of final land preparation.

Fertilizer- It requires 275 kg nitrogen, 25 kg P₂O₅ and 175 kg/ha/year.

Irrigation: Irrigation is given immediately after planting when planting is done in dry days. Thereafter two irrigations are given at 10 days interval to establish the crop. During dry season after each harvest one irrigation and subsequently application of recommended dose of fertilizers are to be followed for optimum herb production. For undulating areas sprinkler irrigation is advisable.

Interculture: Lemon grass has the weed suppression capacity. One hand weeding at 25-30 days followed by one hoeing at 40-60 days after planting is enough to control weeds. **Mulching:** Distillation waste (spent grass) applied as organic mulch @ 3 tons/ha in between the rows has been found very effective in controlling weeds and maintaining soil moisture as well.

Pests and Diseases:

Pest: The most important pest is scale insect, which produces yellow spot on the stem and sucks the sap of the leaves and stem. The insect can be controlled by spraying 0.5 % Dimethoate.

Diseases: Lemongrass may be attacked by leaf blight caused by Carbularia veruciformis that can be controlled by benzimidazole like Benlate 50 WP at 0.2% @ 550-750 litre/ha at 10 days interval.

Harvesting: The crop is perennial in nature and gives good yields for five years. The first harvest is done about 90 days after planting and then at an interval of 55-60 days. Harvesting is done by cutting the grass 10 cm above the ground level. During first year 3 cuttings and subsequently 5 cuttings per year can be taken subject to weather conditions and irrigation management. Both immature and over mature crops give low yield and oil of poor quality. The optimum period of harvesting when grown on hilltop or upper slopes is 75 days while at foothill and plains it is 60days.

Yield:

The average herb yield /ha and oil production is as under:

Year	1st year	2nd year	3rd year	4th year
Herb yield (q)	215	360	360	215
Oil yield at 0.7 % recovery (kg)	150	250	250	150

Oil distillation:

The factors influence the oil yield-

1. Storage of the plantmaterial
2. Treatment of thematerial
3. The method of distillation

The major source of loss is by oxidation and resinification of the essential oils. So, if the material is to be stored before processing. It should be kept in a dry atmosphere with limited air circulation.

The cut grass, when stored in shade, can increase the oil recovery up to 96 hours and storage for a further period will only decrease the oil yield.

Dipping the chopped lemon grass in sodium chloride solution for 24 hours at 1-2% concentration before distillation has been found to increase the citral content.

CHAPTER7(iii) **Production technology ofCitronella**
Botanical name: Cymbopogan winterianus (Java citronella) and Cymbopogannardus

(Ceylone citronella)

Family: Poaceae

Origin: Srilanka

Distribution- It is distributed in tropical and subtropical countries like India, Taiwan, Guatemala, Honduras, Malaysia and Brazil. The important states in our country growing this crop are Assam, Gujarat, Jammu, Kashmir, Karnataka, Maharashtra, Tamil Nadu, West Bengal and Uttar Pradesh.

Major constituent: geranial, citronellal, hydroxyl citronellal etc.

Plant parts used: Leaf and shoots.

Importance:

This is used extensively as source of perfumery chemicals production like geranial, citronellal, hydroxyl citronellal etc.

These are used in perfumery, soaps, toiletries and cosmetics Used in pharmaceuticals.

Used in flavouring industries.

Used as an ingredient in mosquito repellent creams

1. Jorhat- C-2 and Java-2, release from RRL, Jorhat(Assam).
2. NBPGR, Delhi released two strains in Java citronella viz., IW 31243, IW31245.
3. KS-CW-SI-developed through selection by Bidhan Chandra Krishi Viswa Vidyalaya, Kalyani.
4. CIMAP-Bio-13 is the high yielding varieties of this crop for Southern and Eastern India.
5. Manjusha and Mandakini are the varieties released by the CIMAP, Lucknow for the North Indian plains.
6. An elite mutant clone of Manjusha M₃-8 named 'Manjari' which has been found to possess 50-90% more oil, high citronellol and low elemol content on an average, over the other varieties. Manjari is an erect growing herb with yellowish green leaves and a dark purple stem.

Climate: Citronella thrives well under tropical and sub-tropical conditions. It requires humid climate, abundant moisture and sunshine for its good growth. Long drought spells or excessive rainfall is harmful. Citronella is susceptible to frost. Grow well in plains and hills.

Soil: Citronella has been found to grow well under varying soil conditions but sandy loam soil with abundant organic matter is the most suitable for its cultivation. Heavy clay and light textured soils are not good. Calcareous and water logged soils are unsuited. Citronella thrives well in a wide range of soil pH ranging from 5.8 to 8.0. However, a pH of around 6.0 is the most suitable.

Land preparation: The land is brought to a fine tilth by ploughing and harrowing Land is laid out into beds with irrigation channels.

Propagation: Viable seeds are not formed in citronella because of irregularities in meiosis and therefore citronella is propagated through slips, obtained by dividing healthy mature clumps. The bush is gently dug out and separated into a number of slips and each slip contains 1-3 tillers. One year old clump on an average gives about 40-50 slips.

Planting: The slips are planted in May- June. The slips are planted at a distance of 60cm x 60cm apart. However in areas where the soil is very fertile and the climatic conditions support luxuriant growth spacing of 90cm x 90cm may be followed. It is better if the slips are planted on ridges to avoid water –logging. Irrigate immediately after planting. Keep the soil moist for 3 -4 weeks, within which it gets established.

Manures and Fertilizers: It is a soil exhausting crop therefore requires liberal application of manures and fertilizers. In Red soils of Karnataka, where the plant grows throughout the year 10 t/ha of FYM is applied. A fertilizer dose of 200 kg N; 80 kg P and 50 kg K is given. In Tamil Nadu; basal dose of 60 kg P and 50 kg K are to be applied. 125 kg Nitrogen is given in equal splits one month after each cutting. Nitrogen is given in 4 splits in North, 5-6 splits in South. The split doses of Nitrogen are given first one month after planting and the remaining after each harvest at an interval of 3-4 months. The CIMAP, Lucknow, has recommended a spray of 0.5% Fe through ferrous sulphate + Citric acid to check the spread of chlorosis.

Irrigation: Citronella requires sufficient moisture for good growth and yield of leaves. In the areas where the annual rainfall is about 200-250cm, well distributed over the year and humidity is high, supplementary irrigation is not necessary. In the drier months, however, irrigation may be provided and this increases the yield. Java citronella is grown as an

irrigated crop in Karnataka and A.P. It is grown as rain fed crop in high rainfall areas like Assam. 16-20 irrigations are required at 7-10 day interval.

Intercultural: Citronella plantations should be kept weed –free. Check weeds up to 3-4 months after planting and after each cutting. 3 -4 weedings are required per year. Manual weeding or weeding by running a cultivator is done.

Pests and Diseases:

Pests: During dry season the crop may be affected by yellowing and crinkling disease (due to mites). The emerging leaves become wrinkled and pale. It may fail to open and the part may die. This may be controlled by spraying a mixture of Docofol (Kelthane) @ 2 ml/lit and Ethion (Tafethion, 50 EC) @ 1 ml/lit along with a wetting agent like Triton AE or Enditron AE @ 0.5 ml/lit. In the subsequent years stem borer and in rainfed condition termite may infest the crop. These can be controlled by applying Furadan @ 20 kg/ha or by spraying 0.5

% Dimethoate 400 to 500 kg Neem oil cake. Among the insect termites are reported to cause the most damage to the plants.

Diseases: Leaf blight caused by Curvularia sp can be controlled by spraying Mancozebat intervals of 10-15 days. Sheath rot disease caused by Rhizoctonia solani is controlled by spraying Hexaconazole 5%.

The crop sometimes may show yellowing of growing leaves indicating a mixed deficiency of Zinc, Molybdenum and Sulphur. Two or three foliar sprays of a complete micro-nutrient mixture at fortnightly intervals are sufficient to combat the deficiency.

Harvesting: The crop is ready for the first harvest after about 9 months of planting. Harvesting is done by using an ordinary sickle at about 20-45 cm above the ground. Under Karnataka conditions, the crop is harvested in the month of March, June and September. The crop flowers during October – November and the flowering stalks should be nipped off to discourage flowering. If the flowering stalks are allowed to grow, the plants will tend to age very soon and their life span may be reduced. Three to four cuttings are taken per year. Should not be harvested too soon or too late affects the quality of oil adversely. Optimum interval between two cuttings is 90 days; if delayed leaves are partially dried and oil content declines. Generally the crop once planted yields a profitable income for about 3-4 years and should be replanted after this period. Well maintained plantations may thrive longer.

Yield: The yield of leaves may range from 15-20t/ha in the first year and 20-25t/ha in the second and third years. The yield of oil obtained during the first year is about 100-150 kg/ha and in subsequent years about 200-250 kg/ha oil may be obtained. Oil content varies with age, climate, soil fertility and method of distillation.

Distillation: Oil is extracted by steam distillation from herbage. Distil soon after harvest. Semi dried leaves are chopped into bits. Delay in distillation affects aroma and colour of oil.

CHAPTER7(iv)

Production technology of Palmarosa

Botanical name: *Cymbopogon martini* var motia

Family: Poaceae/Graminae

Origin: India

Distribution: Outside India, the crop is grown commercially in Indonesia, the East African countries, Cuba and Brazil. Grows wild in forests of A.P, M.P, Maharashtra and Karnataka.

Major constituent: Geraniol

Plant parts used: Tender stems, leaves and flower stalks

Description of the plant: Palmarosa is an aromatic, perennial grass, which attains a height of 2-3 m. The aerial parts die in the winter. Being very susceptible to frost, its leaves and shoots may dry up even in November when there is early frost, but usually withering starts in December, and by the end of January the plant dries up completely.

Importance and Uses:

Essential oil from palmarosa (Rusha or Rosha) is used to extract Geraniol.

The essential oil (geraniol) has rose like aroma hence useful for

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perfume, soap and tobacco industries.

Oil of palmarosa is one of the most important essential oils. Oil of palmarosa chiefly contains 70-80 % geraniol.

The palmarosa oil occupies 3rd place in the export of essential oil.

Climate: Hardy and drought resistant plant. It grows well in areas receiving 100 – 150 cm annual rainfall. Winter should be less severe. Exposure to sunlight is essential. It does not perform under shade.

Soil: Light loamy soils with good water infiltration are ideal.

Varieties:

Motia: This variety is also referred as “Rosha grass” or “Russa grass” and yields oil with a high geraniol content (75.90%), which is also called East Indian Geranium Oil or Russa Oil.

Sofia: It is known as ginger grass and grown wildly in India and it yields oil of lower geraniol content.

IW 31244: Released by NBPGR

RRL (B) – 77 and RRL (B) 71: Released by RRL, Bhubaneswar.

Trishna and Tripta – Hybrid developed by CIMAP, Lucknow. Give 40% more oil and has 93% Geraniol.

Some of the high yielding varieties under this crop are Sel. IW-31243 and IW-31245, released under the All India Co-ordinated project on the improvement of Medicinal and Aromatic Plants from the CIMAP Lucknow.

PRC-1 is another important variety recommended for cultivation.

Propagation: By seed and rooted slips.

Nursery raising: First a nursery is raised. Beds are raised well prepared and well manured. Seeds @ 2.5 kg per ha is sown at 15-20 cm spaced lines. Sowing is done during May – June. Nursery beds are irrigated daily. Germination will be completed within 2 weeks and seedlings ready in 30-40 days (15-20 cm height).

Slips: Slips are collected from elite clump. They are separated and planted during April – May. Ready for transplanting after 3 months during June- July or August - September. Oil yield is higher with clonal propagation. Percentage of establishment is higher with seedlings.

Land preparation: The main field for raising palmarosa should be prepared by ploughing 3-4 times, followed by forming ridges and furrows at 90 cm apart. The seedlings are transplanted at 60 cm spacing in the ridges.

Planting: Planted during June- July. Irrigate immediately.

Manures and fertilizers: If grown on fertile soils, does not manure during the first year as it promotes vegetative growth and reduce oil yield.

In less fertile soils, basally 10 t FYM; 20 kg N; 50 kg P and 40 kg K per ha are to be applied.

Top dressing with 40 kg Nitrogen each time for three times starting

from 45 days after planting is to be done. Micronutrient like zinc ($ZnSO_4$ 25 Kg/ha) is beneficial to increase the oil yield of palmarosa.

Irrigation: If rainfall is more than 150 cm, the crop can be grown as rain fed crop. If rainfall is less than that, irrigation has to be given at 7 – 10 day interval. When the crop is fully grown, irrigate at 15-20 day interval. Yields reduced if field becomes dry.

Weeding: Keep the field weed free for the first 2-3 months after planting and one month after each harvest.

Pests and diseases: The crop is not attacked by any pest or disease of a serious nature. Leaf blight and the symptoms of yellowing of leaves and necrosis and leaf spot are reported in the crop.

Harvesting: First harvest is taken in 4-5 months after planting. Harvest 15-20 cm above the ground at the time of flowering to early seed formation stage. Subsequently the crop is harvested at 2½ to 3 months interval for 3-4 years.

The right time for harvesting is when the plants just begin to bloom as the leaves contain higher oil content during the blooming period. The grass yield more oil recovery if dried for nearly one week. The steam distillation seems to be better than the other type of extraction.

Yield: Palmarosa yields 15 to 20 tonnes of herbage per ha in a year with oil yield of 50-60 Kg per year. The plantation can be maintained for about 8 to 10 years, but the oily yield starts declining from the fifth year. Yield increases up to 4th year.

Distillation: Oil is extracted by steam distillation. Herbage is shade dried for 24 hours and chopped for distillation. Oil recovery is 0.3 to 0.4%. It takes 4 hours for complete recovery of the oil.

Botanical name: Ocimum sanctum L.

Family: Lamiaceae: Labiateae

Plant parts used: Leaves, seeds, roots

Major constituent: Eugenol(71%), Eugenol Methyl Ether (20%)

Origin: India

Distribution: Ocimum has wide distributions, covering the entire Indian subcontinent, ascending up to 1,800 m in the Himalayas and as far as the Andaman and Nicobar Islands. This plant-occupies a wide range of habitats.

Description of the plant: It is much branched, perennial, herb with purplish tinged quadrangular stem and 30-75 cm tall. Leaves are simple, petiolate, opposite, sub-ovate and serrate possessing glandular hair which secretes aromatic oil. The flowers are small, protandrous, highly cross pollinated.

Importance and Uses:

The plant is also used as a pot herb: its leaves are used as a condiment in salads, and other dishes.

The leaves, seed and root are medicinally useful.

The leaves also contain ascorbic acid (82 mg 100 g) and carotene (2.5 mg/100 g).

The juice of the leaves possesses diaphoretic, antiperiodic. Stimulating, expectorant and antipyretic properties.

It is used in bronchitis, applied to the skin in ringworm and other cutaneous diseases and as drops to relieve earache.

An infusion of the leaves is used as a stomachic in gastric disorders of children. If taken internally, it strengthens the liver and heart and is a good appetizer.

It cures amenorrhea and promotes the secretion of milk in lactating women. The leaves, if chewed, give relief from toothache.

The leaf-juice is applied to reduce inflammations.

The seeds rubbed with cow's milk are given for vomiting and diarrhea.

The juice of the fresh leaves, flower-tops and the slender roots are considered to be good antidotes for snakebite and scorpion sting.

It has marked insecticidal activity against mosquitoes.

Types and Varieties: In India, two types of *O.sanctum* are under cultivation:

1. Green type (Sri Tulsi)- is the most common
2. Purple type (Krishna Tulsi)- bears purple leaves and is preferred in the trade for its higher potency of the drug.

Recently released varieties are CIM-Angana and CIM-Soumya.

Climate: Flourishes well under high rainfall with humid conditions. Long days and high temperatures favours good growth and higher yields

Soil: Wide variety of soils from rich loam to poor laterite soils—saline, alkaline, slightly acidic. Well drained soil suitable for good growth and high yields.

Propagation: Propagated by seeds. These seeds are likely to deteriorate in future generations on account of the highly cross-pollinated nature of the crop. Hence, for fresh plantings, the growers have to take fresh seeds.

Nursery: Prepared raised beds of 15' x 4' x 9" size and well manured by the addition of FYM. About 200-300 g seeds are enough to raise seedlings for planting one hectare of land. The seeds should be sown 2 cm deep in the nursery-beds. After sowing the seeds in the nursery, a mixture of FYM and soil is thinly spread over the seeds and irrigated with a sprinkler-hose. The seeds germinate in 8-12 days and the seedlings are ready for transplanting in about 6 weeks time, at the 4-5 leaf stage.

Land Preparation: The land is brought to a fine tilth and laid out into plots of convenient sizes for irrigation. It is preferable to add 15t/ha of FYM during the preparation of the land.

Transplanting: It is recommended to plant the seedlings at a distance of 40 x 40 cm, 40 x 50 cm and 50 x 30 cm to get high herbage and oil-yield per hectare at Lucknow, New Delhi and Indore, respectively. The plots are irrigated immediately after transplanting. The seedlings will establish well by the time of the second irrigation. At this stage gap filling and replacement of the poor plants is done so that a uniform stand is achieved.

Season: The nursery can be raised in the third week of February and transplanting is generally started in the middle of April. This can be undertaken in the month of March, if the seedlings are raised in beds.

Fertilization: 120 kg N/ha 60 kg P₂O₅/ha. Half the dose of N and the entire dose of P₂O₅ are given as a basal dose. The remaining N is applied in two split doses, after the first and

second cuttings. The application of the micronutrients Co and Mn at 50 and 100 ppm concentrations, respectively, is reported to increase the oil-yield significantly.

Irrigation: Irrigation depends upon the moisture content of the soil. In summer, 3 irrigations per month are necessary whereas, during the remaining period, it should be done as and when required, except in the rainy season when no irrigation is necessary. Altogether, about 12-15 irrigations are sufficient in a year.

Weeding: The first weeding is done one month after planting, and the second 4 weeks after the first. After this, no further weeding is required as the plants become bushy, thereby naturally suppressing the weeds.

Interculture: One hoeing, two months after planting, is sufficient. The crop may also be earthed-up at this stage.

Diseases and pests:

Pests

Among the insects, the larvae of leaf-rollers sticking to the under surface of the leaves fold them backwards lengthwise, thus webbing them. Malathion (0.2%) may be sprayed to control this insect.

Diseases

The plant is susceptible to powdery mildew caused by Oidium spp., seedling blight caused by Rhizoctonia solani and root-rot caused by Rhizoctonia bataticola. Powdery mildew can be controlled by spraying wettable sulphur (4 g/l of water), and the latter two diseases are managed by improved phyto-sanitary measures and by drenching the nursery-beds with a solution of mercurial fungicide.

Harvesting and Yield: Harvesting at full bloom stage and first harvest at 90-95 after planting and afterwards, it may be harvested at 65- 75 days' intervals. Cut 15-20 cm from ground level. Harvesting should be done on bright, sunny days in order to obtain good quality oil-yield.

Yield: About 5 t /ha twice or thrice year and whole herb contain 0.1-0.23% essential oil. Oil yield is 10-23 kg/ha.

Distillation of Oil

The harvested produce is usually distilled in its fresh form. However, the oil quality and yield do not diminish up to 6-8 hours after harvest, but any further delay may cause considerable loss in yield and quality of oil. Steam-distillation is found to be superior to water distillation. The whole herb contains 0.1 to 0.23% essential oil. The yield of oil varies with the type, season and place of origin. The oil yield will be approximately 10-23 kg/ha.

CHAPTER7(vi)

Production technology of Rose

Botanical Name: Rosa damascena Mill

Family: Rosaceae

Plant parts used: Flower

Origin: Indigenous to Europe

Distribution: Bulgaria, Turkey, France, Italy, Morocco, Russia and India are the main countries where it is cultivated in large scale for the oil production. In India it is commercially cultivated in some parts of UP, Haldi Ghati and Pushkar in Rajasthan and in Jammu and Kashmir.

Description of the plant: It is perennial, hardy shrub with long life span of 20-30 years under cultivation. It grows to a height of 2.5 to 3 m. Leaf is compound type having 5-6 leaflets. Flowers are scented pink, red and sometimes white or striped.

Rose Products: Rose oil, Rose concrete and absolute, Rose water, Rose Attar, Gulkand, Gulroghan, Pankhuri, Dried rose buds etc.

Varieties: Indica, Jwala, Super jwala, Himroz, Hot himroz. Jwala is suitable for cultivation in subtropical northern plains, mid-hills and mild temperate regions up to 1200 m altitude, Himroz is suitable for cultivation in mild temperate to cold temperate regions (1200 to 2500 m altitude). It is cold tolerant and grows in temperate areas without any visual sign of winter injury to flower buds.

Climate: Mild temperate climate is best suited. At the time of flowering, the temperature should be between 25 °C to 30 °C and relative humidity above 60%. High air humidity above 60% and moderate temperature 15 °C to 20 °C gives more flower yield.

Soil: The roses flourish well at the foot hills. It withstands wide range of soil pH conditions from 6 to 8 and silty clay loam to sandyloam.

Propagation: It is propagated through one year old stem cuttings. Stem cuttings are collected at the time of pruning in mid October to end of December, 20 cm long and 0.75- 1.50 cm thick cuttings are planted in nursery, 2/3 of the length is inserted into soil, IBA @ 200-250 ppm is given to induce rooting. These cuttings are ready after one year for transplanting into main field.

Planting time: November to mid January. Rose plants can be also be planted in the month of rainy season.

Planting distance: 1 m x 1 m or 1 m x 0.5 m

Pit size: 45 x 45 x 45 cm in good soil and 60 x 60 x 60 cm in poor soil

Irrigation: Plants are irrigated immediately after planting. After that 12-15 days intervals during peak periods. However, when plants are established properly after two years, frequency of the irrigation may be reduced.

Interculture: It is required to keep the plants free of weeds after planting. Usually 2-3 times weeding and hoeing are required to be done during first year.

Manure and fertilizers: FYM 15-20 tonnes/ha and 100-120 kg NPK (18:32:16) mixed fertilizer should be applied at the time of transplanting of rooted cuttings into the pits. After two year, 160-200 kg nitrogen, 60-90 kg phosphorus and 40-60 kg potash per hectare per year are needed in rose plantation.

Pruning: Pruning is very important operation in Rosa damascena. It requires a dormant or resting period before flowering. Best time of pruning is October in North India. **Insect and pest:** Aphids, Caterpillars, Thrips, Red Spider Mite

Disease: Black Spot, Rust, Powdery Mildew, Downy Mildew

Harvesting: The flowers are harvested in the early hours of the day when they just open.

Flowers are plucked by hand being nipped of just below the calyx.

Yield: Well maintained Rose plantation yields about 3.5- 4.5 tonnes of flowers /ha/year.

Distillation: Oil is extracted by steam distillation. Flower petals used for oil extraction.

Oil recovery: 0.025-0.030%

Oil yield: 0.75 – 1.5 kg/ha

Rose concrete: 0.35-0.45%

Rose absolute: 0.15-0.20%

CHAPTER7(vii)**Production technology of Geranium**

Botanical name: Pelargoniumgraveolens

Family: Geraniaceae

Origin and distribution: Geranium is a native of the Cape Province in South Africa. It is commercially cultivated in France, Belgium, Spain, Morocco, Madagascar, Egypt, Reunion Island, Congo, China and India. Presently, it is being commercially cultivated mainly in the Nilgiris and Kodaikanal Hills of Tamil Nadu and in and around Bangalore in Karnataka, also in Uttarkhand.

Plant parts used: Leaves and terminal shoots

Major constituent: The chief constituent of the oil is geraniol and citronellol.

Importance and uses:

Geranium is one of the important aromatic plants, yielding an essential oil which is highly priced for its very profound and strong rose-like odour. The plant is also known as rose geranium.

Chief constituent are Geraniol 68 to 75% and Citronellol (23 – 40%).

The pure scented geranium oil is almost a perfume by itself and blends well with all other perfumes.

It is widely used in scenting soaps and for the isolation of rhodinal which forms part of most high-grade perfumes.

India is importing more than 20 t of this oil from other countries to meet the local demands of the Indian perfumery industries.

Scented geranium is a bushy, aromatic plant. The stem is cylindrical, woody at the base, pubescent, green when young and turning brown with age. The leaves are highly aromatic in nature.

Types of rose geranium: There are two types of rose geraniums

1. **Algerian or Tunician:** This type of scented geranium is slender with flowers of a dark pink colour. It is being grown in the Nilgiris and is unsuitable for wet conditions. This variety yields 50-60% more oil with a more delicate odour than that of the Reunion type.
2. **Bourbon or Reunion:** Grown in the Nilgiris and Anamalai hills, the plant is sturdy with light-pink flowers and more suitable for wet conditions. The oil

content is higher during the summer months from April to June. The terminal portion with 6 to 12 leaves contains more oil than the middle and basal portions.

Varieties:

Kodaikanal-1: Released by HRS, Kodaikanal (TNAU) give high herbage (45.2 t per ha) and oil yield (54 kg) oil contains 60 % of geraniol.

KKL-1: This is the Algerian and Reunion type variety, the clone PG-7 recorded 0.3% essential oil has been released under the name 'KKL-1' at the Horticultural Research Station, Kodaikanal.

Sel-8: The Indian Institute of Horticultural Research (IIHR), Bangalore, has found 'Sel-8' a Reunion type, as the highest yielder under Bangalore conditions and has recommended for cultivation.

Hemanti, Bipuli, and Kunti are the other varieties released by the CIMAP, Lucknow, for cultivation in the plains of North India.

Kelkar and Ooty, are the other varieties available in this crop.

Climate: Scented geranium can be grown in temperate, subtropical and tropical climates at various altitudes from 1 000 to 2 200 m. It thrives best in subtropical climates with a temperature ranging from 5°C to 23°C. However, temperatures below 3°C will kill the plant. Warm winters coupled with mild summer temperatures and, well-distributed annual rainfall ranging from 100-150 cm is ideal. However, heavy rainfall results in water-logging, causes root-rot and stunted growth. It has been observed that it grows equally well at much lower altitudes and tolerates higher temperatures up to 43° C in the plains when grown under irrigated conditions.

Soil: Scented geranium is shallow-rooted crop and it requires well drained deep, porous soil rich in organic matter. Scented geranium perform well in red lateritic soils with a pH range of 5.5-8.0, though a calcium rich porous soil is the best.

Propagation: Scented geranium is easily propagated by cuttings, since there is no seed setting in scented geranium, vegetative propagation is must. Terminal cuttings of stem about 20 cm long and consisting of about 8 nodes are the best suited for propagation. Cuttings are taken from healthy, vigorously growing plants during November. Cuttings are defoliated except top 3-4 leaves. Slanting cut is made just below a node. Bottoms of cuttings are dipped in 0.3% Benlate or Bavistin 0.1% and then in rooting plant growth regulators like IBA or IAA at 200 ppm. The cuttings are planted in raised beds of 3 m long and 1 m wide. The soil should be well mixed with powdered FYM. The cuttings are planted with at least two nodes

buried in the soil at a spacing of 8-10 cm. Before root initiation, temporary shade is provided and the beds are watered regularly. Cuttings root in 30-40 days and ready for planting within 60 days after planting. 80mx80m nursery is sufficient for one ha.

Recently, its propagation through leaf petioles has also been reported to give a good rooting percentage (75%), which will help to multiply this plant in larger numbers than the traditional method of propagation using 20 cm-long cuttings. The CIMAP, Lucknow, has developed a protocol for large-scale production of scented geranium calli-clones and plants have been obtained under field conditions with improved oil-yield and quality.

Land preparation: Ploughing, harrowing and planking are to be done thoroughly for preparation of land. Manures, P and K are applied at the last ploughing and incorporated. The land is laid out into ridges and furrows.

Planting: Healthy and disease free rooted cuttings with well developed root system and a crown of leaves are selected for planting. The cuttings are carefully dug out from the nursery and planted at a spacing of 60 cm x 60 cm. Planting should be done during May- June in hilly areas and December- January in plains. Irrigate on alternate days for a month and later at weekly intervals. Plants establish within two months.

Manures and fertilizers:

Prior to transplanting the cuttings, 10 t of FYM, 35 kg N, 35 kg P₂O₅ and 35 kg K₂O/ha are incorporated into the soil.

A second dose of nitrogen at 35 kg/ha is applied about 2 months after the first application. Further, nitrogen is given in two equal split doses for each harvest-the first dose being just after the crop is harvested and the second two months later.

In addition, the application of 20 kg/ha of zinc sulphate and 10 kg/ha of boron has been reported to increase the herbage yield. Similarly, an application of copper (20 kg/ha) and molybdenum (30 kg/ha/year) in four split doses after each harvest has been found to increase the yield.

Irrigation: Plants are irrigated immediately after planting. Irrigation is continued on alternate days for about 10-15 days and then reduced to twice a week. The schedule is modified during the winter and summer months at intervals of 7 to 10 days, depending on the situation. Though scented geranium tolerates short periods of drought, water-logging of the crop must be completely avoided.

Interculture: Keep the field weed free during the first 2-3 months after planting and up to one month after every harvest. Mulching helps in reducing weed infestation, the number of irrigations and produced less weed biomass.

Pests and diseases: The incidence of pest and disease is not severe in the geranium crop. However, it is found to be affected by root knot nematodes and wilt disease.

Roots-knot nematodes (Meloidogyne incognita and M. hapla): Affect the Scented geranium plant. Application of Aldicarb @ 20 kg/ha to the soil reduces the incidence of root-knot.

Wilt: The crop is affected by wilt disease, caused by the Fusarium species, and Botrydeplodia theobromae, which are soil borne fungi. Dip the cuttings in 0.03% Benlate solution at the time of planting in the nursery. Prior to transplanting the rooted cuttings must be again dipped in 0.03% Benlate solution and then planted. The crop is sprayed with 0.03% Benlate solution about 2 weeks before it is harvested.

Harvesting: Geranium is harvested 4-5 months after transplanting, when the leaves begin to turn light-green and exhibit a change from a lemon-like odour to that of rose. However, this requires careful observation and experience. The crop should be harvested using a sharp sickle and sent for distillation immediately. After every harvest, hoeing, fertilizer application and irrigation are done according to the schedule. The plant then puts forth fresh shoots, grows faster, and reaches the next harvesting stage in 4 months. Thus, a total of 3 harvests can be obtained for 3-6 years. The oil content is higher during the summer months, from April to June. The terminal portion with 6-12 leaves contains more oil than the middle and basal portions.

Yield: The quality and yield of oil will be better if the crop is harvested at the appropriate time of maturity. For a higher yield, a good plant population in the field is necessary. A minimum of 25,000 plants should be maintained in a hectare in a year which, in turn, may yield 15 kg of oil on steam-distillation. The recovery of the oil ranges from 0.08 to 0.15%, depending upon the season of harvest and type of material. Cultivation under poly house cover is reported to increase herb and oil yields up to 53% over the conventional planting of the scented geranium crop.

Distillation: The freshly-harvested terminals are used for the distillation of oil. The oil is extracted by a simple steam distillation method.

CHAPTER7(viii)

Production technology ofVetiver

Botanical name: *Vetiveria zizanioides*(syn. *Chrysopogon zizanioides*)

Family: Poaceae

Origin: India and Srilanka

Distribution: Vetiver is indigenous to the Indian subcontinent and is widely distributed in tropical Asia, Africa and Australia. It is cultivated extensively in Java, Reunion Island, Indonesia, Haiti, Jamaica, Zaire, Vietnam and Brazil. In India it is found growing wild in the forests of Rajasthan and Uttar Pradesh. It is also found in some parts of Assam, Jammu, Bihar, Orissa, Andhra Pradesh and Karnataka. However it is systematically cultivated as a crop in Kerala and Karnataka.

Plant parts used: Roots

Major constituents: The major constituents are vetivone, vetiverols, vetiverenyl, vetovernate, benzoic acid and palmiticacid.

Importance and uses:

The economic part of the plant is the root, which possesses a most agreeable aroma and is employed to scent clothes, either by itself or in the form of sachets.

The oil of vetiver is one of the most valuable and most important

perfumer's raw materials, widely used in perfumeries, cosmetics and for the scenting of soaps. It also acts as a natural fixative.

The oil of vetiver blends well with other oils particularly with sandalwood, patchouli and rose.

Medicinally it is reported to be used as a carminative in flatulence and as anthelmintic and possesses stimulant and refrigerant properties.

It is locally applied to relieve pains on the body

Roots are used to make mats, brooms, screens, mattresses along with bamboo. Roots are used in pharmaceuticals.

Young leaves are used as fodder and bedding for horses and cattle. Dry Leaves are used as roofing material and for mulching.

It is one of the best soil-binders and is being used extensively in arid zones to check soil erosion.

Varieties: The grass growing wild in North India and that cultivated in South India are two different types. Thus there are two main types of vetiver namely-

1. Flowering or seeding type: They grow wild in North India. The North Indian type is poor in oil yield, but its oil quality is superior. Oil from North Indian types has superior aroma. Ex. Akhila, Bharatpur, Musanagar.
2. Nonflowering or nonseeding type: They grow in South India. The south Indian type vetiver is good in oil yield, but the quality is inferior.

Improved Varieties:

The CIMAP has developed two superior clones, KS-1 and KS-2 from a collection from Bharatpur. An improved tetraploid strain "Sugandha" has also been released by the CIMAP and is reported to be superior in terms of oil-yield. Pusa hybrids (1-30) have been evolved by NBPGR, New Delhi. Of these F1 hybrids Hyb-26 gives higher yield of roots (14.5q/ha) with an oil content of 1.50%. Whereas hybrids 26, 7 and 16 perform better in saline and alkaline soils with high root and oil yield.

Under Bangalore conditions, hybrid -8 has been found to be better. Its roots yield 1% essential oil and possess 70-85% vetiver oil content. The yield of root ranged from 12-15q/ha when harvested at 15 months age. A vetiver clone ODV-3 developed at Aromatic and Medicinal Plants Research Station, Odakkali is reported to give good root and oil yield in Kerala.

The CIMAP, Lucknow has released few new varieties based on the oil odour value. They are Kesari, Gulabi and Dharini.

Climate: The crop prefers tropical and subtropical climate for its proper growth, development and essential oil yield. It prefers mild climate for the best performance. It is cultivated in 100-400 cm rainfall in South India, as well as in Bharatpur area in Rajasthan receiving scanty rain. Shade has unfavourable influence on root growth. It stands well against winds and storms.

Soil: Vetiver can be grown on almost every kind of soil. Light soils, however, should be avoided as the roots obtained produce a very low percentage of oil. Well drained, sandy loam and red lateritic soil rich in organic matter are considered to be ideal as the roots produced in such soils are thick and contain more essential oil. It can be grown even in saline and alkaline

soils, with a pH range of 8.5 to 10.0. Compact heavy soils restrict root growth and pulling out of roots is difficult.

Land preparation: The land is ploughed to a depth of 20-25cm repeatedly and the soil is mixed with the recommended dose of manure and fertilizers and made ready for planting. **Propagation:** Vetiver can be propagated through seeds or slips. Seeding is found to be profuse in the crop, in areas where it occurs in the wild and regeneration takes place from self-sown seeds. In south India where the crop is cultivated on a large scale, the non-seeding type is grown. This is propagated from slips obtained from the uprooted clumps of the previous crop.

Planting: Best time is June- July, at the advent of the rainy season. If irrigation facilities are available, it is better to plant during March- April. Slips of 15-20 cm long are separated from clumps. Top portions are cut. Two or three slips are planted in each hole of 5-8 cm depth and the soil is pressed around the hole. Vetiver is planted in rows 45 cm apart with a plant to plant distance of 30cm. A spacing of 60 x 25 cm is also recommended to allow 60 000 plants/ha. Planting should be done when there is adequate soil moisture. Irrigate immediately after planting. Give irrigations up to 10-15 days till slips establish.

Manures and fertilizers: Vetiver crop may be supported with 10 t FYM, 25kg/ha each of N, P and K for obtain economic yields. While the entire quantity of FYM, half N and a full dose of P and K are applied at the time of planting, the remaining half of N is given after about 6 months of planting. A fertilizer dose of 60 kg N, 22.5 each of P_2O_5 and K_2O is recommended in Kerala.

Irrigation: In areas where rainfall is good and well distributed throughout the year and humidity is high, supplemental irrigation is not necessary. However, in drier areas, about 8-10 irrigations will be required in order to obtain the optimum yield.

Inter culture: Once the plants have established and grown into bushes, the weed problem is not severe because of the nature of the bushes. However, in the newly established plantations, 3-4 weeding are necessary until the bushes are formed.

Pests and diseases:

Pests: There are no serious insect pests except for the ants attack the roots.

Diseases: Very few diseases have been reported on vetiver. During the rainy season the plant is attacked by Fusarium spp. It can be effectively controlled by drenching the soil with Bordeaux mixture (1%).

Harvesting:

The crop planted in July should be harvested after 18 months to get the maximum oil yield.

Oil content and yield are less during rainy season as the oil is diffused into soil. Plants produce new roots during rainy season so oil synthesis is reduced.

Harvesting roots during dry season from December to February is more preferable.

Above ground portions are cut to 15 to 20 cm above the ground. Clumps are uprooted by digging forks. Soil is dug up to 30 to 40 cm.

Clumps are beaten to remove adhering soil and roots are separated from the base, washed and dried under shade for 1-2 days before distillation.

Yield: 5-6 tonnes of roots per ha. It gives 15 to 16 kg of oil and 1 to 1.5 per cent oil on dry weight basis. A root yield of up to 14-18 q/ha has been obtained in North India. The oil contains 65 to 75 per cent Vetiverol.

Distillation: Oil is extracted by steam distillation. Herbage is steeped in water for 12 hours, chopped to 5-10 cm long bits and distilled.

Processing in Ornamental Crops

When conditions are not suitable for storage or immediate marketing of fresh produce, many flower crops can be processed using simple technologies.

There are different methods to extract essential oil from flowers

- 1. Enfleurage or Cold fatextraction**
- 2. Maceration or hot fatextraction**
- 3. Solvent extraction (Petroleum ether andbenzene)**
- 4. Super-critical fluid extraction**

1. Enfleurage or Cold fatextraction

Enfleurage is one of the oldest methods of extracting essential oils and is rarely used these days because of its high cost. It involves placing the flower petals on a layer of glass that is first spread with a thin layer of fat called "chassis". The volatile oil diffuses into the fat, then the fat is collected and the oil is extracted from the fat using alcohol.

Once the alcohol evaporates what is left behind is called the absolute. As you can imagine, this is a very time-consuming process, but it was the only way to extract delicate flowers like Jasmine for a very longtime!

Jasmine and tuberose give their greatest yield of flower oil upon extraction with cold fat (enfleurage) because their physiological activities continue for 24 hr. and longer after harvesting. During this period, the fat on the chassis absorbs the perfume emitted by these flowers.

2. Maceration or hot fatextraction

The flowers are extracted by immersion in hot fat. In other words, the same batch of hot fat is systematically treated with several batches of fresh flowers until the fat becomes quite saturated with flower perfume. The exhausted flowers are removed and the fragrant fat, called Pomade d'Orange, Pomade de Rose, etc., is sold as such, or the pomade may be treated further by washing it with strong alcohol, exactly as with jasmine or tuberose pomades, obtained by cold enfleurage. The alcoholic extracts (Extrait d'Orange, Extrait de Rose, etc.) may be marketed as such, or they are concentrated in vacuo, giving thereby the corresponding absolutes of pomade.

3. Solvent extraction

Solvent extraction, also called liquid-liquid extraction or partitioning, is a procedure used to separate compounds based on their solubility in two immiscible liquids, usually water and an organic solvent.

Whenever an oil with natural flavor is required, direct extraction with solvents such as petroleum ether or benzene is practiced.

The solvent is first allowed to run slowly through the flowers, washing out the essential oils and waxes. The solvent is then allowed to evaporate under vacuum, leaving behind a semi solid residue of essential oils and waxes in the retort. The mass is then treated with alcohol to dissolve out the essential oil, the waxes being removed by filtration or precipitated out by freezing. Later, the alcohol can be evaporated to isolate the floral absolute.

4. Super-critical fluid extraction

CO₂ is the most popular solvent used in Super-critical fluid extraction. It has been reported that aroma of extracts using supercritical CO₂ better resemble the aroma of the natural plant than steam distilled extracts.

Value Addition of Flowers through Dry Flower Technology

Dry flowers preserve special gift bouquets, creating a beautiful long-lasting arrangement for indoors. They add value to create decorative centerpieces for home with the benefit that they require very little maintenance that too in the days of flower scarcity. Dry flowers have good demand both in Indian and international markets. From India it is being exported to countries like USA, Japan and Europe. India stands first in dry flower export owing to the availability of variety of plants. Dry flowers do not mean only flower parts, but also includes dried shoots, seeds and barks. Export of dried flowers and plants from India is about Rs 100 crore per year. The industry exports 500 varieties of flowers to 20 countries. They are widely used to make handmade paper, lampshades, candle holders, jute bags, photo frames, boxes, books, wall quilts, topiary, cards and several gifts. The use of dry flowers in making of these products enhances the appearance and beauty of these products.

Tips of Picking and Drying Dried Flowers

- Since drying will emphasize imperfections, hence quality flowers should be chosen for drying.

- Blue, orange and pink flowers retain best color on drying.
- Pickingshouldbedonewhenthedewevaratesfromtheflowers.
- Picking of flower in dry weather is best.
- Most flowers should be picked when they are at their peak and are starting to open up. Picked flowers should be immersed in a bucket of lukewarm water in a cool, dry place.
- Harvested stems should be grouped into bunch using rubber band.
- Dried flowers should be kept away from sunlight.
- Excessive heat, humidity and dust must be avoided to prevent colour fading.
- Dried flowers should be cleaned regularly by blowing off the dust, using either a hair dryer on the no-heat setting or by using canned air.
- No matter which method has been used to dry the flowers, they should then be sprayed with an aerosol sealer to help hold their color and minimize or prevent shattering.
- Avoid using anything sticky, like hairspray, which will attract dust.

Materials and Methods of preserving flowers

- Generally flowers are dried by three basic techniques that is hanging, pressing and via use of desiccants.
 - To hang or air-dry flowers, one needs floral wire, rubber bands and string.
 - To press flowers, one needs a stack of heavy books or a flower press and wax paper or blotting paper.
 - To dry flowers using a desiccant, one needs silica gel, borax or sand.
- There are many ways to dry or preserve plant materials. Air drying is the most common and easiest, flowers dried in silica gel keep their colour and form well and glycerine preservation is recommended for foliage and berries
 - There are at least five ways to preserve the beauty of garden flowers to brighten up the dull days of winter.
 - Many blossoms, such as strawflowers (*Helichrysum bracteatum*), most daisies, celosia, baby's-breath (*Gypsophila elegans*), statice (*Limonium sinuatum*), and the annual ornamental grasses, can be air-dried in a number of ways. Whatever the species, first remove all the leaves, then find a room or area that is reasonably dark but has plenty of ventilation.
- Flowers with stiff stems, such as bells-of-Ireland (*Moluccella laevis*), can simply be placed in a glass jar or vase until they are dry. Those that are floppy can

be hung upside down in loose bundles from individual nails or hooks, or a number of bunches can be attached to wire clotheshangers.

- One can staple a big square of chicken wire to a wooden frame, and suspend the flowers with the stems hanging through the holes.
- Often when a vase of flowers is forgotten for weeks, the owner will suddenly find the water has long gone but the flowers have dried naturally. This method works especially well for drying leaves.
- Another good method for drying flowers employs the fine white sand that is sold at building and home centers and used for filling children's sandboxes. First find a strong plastic or wooden box that can withstand the weight of the sand and then spread an inch-deep layer of sand on the bottom. Carefully place the flowers on that base and slowly sprinkle dry sand over and about the flowers until they are completely covered. Do not cover the container. Check after three weeks have passed to see if the flowers are dry.

Dry Flower Techniques: Broadly flower drying comprises of various drying techniques and dyeing process.

A. Drying

AirDrying

Airdrying is done in a warm, dry place with adequate air circulation. Drying naturally in the air produces some of the best results. It is the preferred method for large-scale drying operations. Most plants dry best when tied in bunches and hung upside down by removing all leaves. Six to ten stems ends are tied together about two inches from the stem ends with the help of a rubber band. Plants are thoroughly dried in three weeks when the stems snap easily. Chinese lanterns, baby's wreath, poppy seed-heads and globe thistles dry better right-side up. Simply plants are placed in a wide-mouth jar or coffee can to dry. Foliage and grasses can be air dried by laying them on newspaper or cardboard. Globe Amaranth, strawflowers and immortelle have weak stems. These stems should be removed and replaced with florist's wire before the flower is dried. Stem of plant is cut 1/2-inch below the flower and floral wire is inserted up through the remaining stem and through out the center of the flower. A hook is made at the top of the wire and is pulled back down into the flower. The stem around the wire shrinks and dry up tightly. Once the flower is dry, floral stem is wrapped with the help of tape and wire. To strengthen dried flowers, clear lacquer, hairspray or clear crafts spray is sprayed.

Water Drying

Although it sounds improbable, some flowers can be dried well in water. One needs to strip the leaves and put the stems in about 2 inches of water and leave to rest in a dry, dark and warm location. The water is then absorbed by the flowers and evaporated. Yarrow, hydrangeas, bells of Ireland, ageratums, alliums, acacia, celosia and gypsophila take well to water drying. Because they are top-heavy, it's best to dry fennel, dill, Queen-Anne's-lace and edelweiss by placing the stems through the holes in 1/4-inch hardware cloth. The hardware cloth will support the heavy heads, while the stems hang loosely below.

Microwave Drying

Flowers can also be dried in a microwave oven. In this case, bury the flowers in a desiccant as outlined above, but do not cover. Place the container into the microwave and 'cook' at a low-medium setting (the 'defrost' setting on many ovens) for about 2 ½ minutes, or, if you have a microwaveable thermometer that you can read from outside the oven, until the silica near the buried flower reaches approximately 160° F. When the container of dried flowers is removed from the microwave oven, place a lid (slightly vented) on it, and allow it to sit for about 24 hours before carefully uncovering the flowers. Since ovens, drying agents, and flowers all vary considerably, it's best to experiment with this technique before committing 'good' flowers to the process. Usually foliage is suitable for microwaved drying.

Desiccant Drying

Perhaps the best way to dry flowers is by using a desiccant in which flowers are buried until they have dried. By using this method, the shapes and colors of more dimensional flowers like roses, carnations, marigolds, lilies, and dahlias can be preserved in the dried state. Old-fashioned home mixtures, such as borax and white cornmeal (2:1) or borax and sand (2:1) may be used. But the best and fastest way is to use silica gel (actually a dry, granular material), which has the capacity to absorb large quantities of moisture and can quickly dehydrate fresh flowers.

Silica Gel Drying

Flowers dried in desiccants retain best color and shape. Silica desiccants are most popular, and can be purchased at hobby and craft stores. Follow the package directions for best results. In Silica Gel multipetaled flowers, such as dahlias, zinnias and daisies, dry best in silica gel (found at craft and hobby stores). Place flower heads face up on a 1-

inch bed of silica gel crystals in an airtight container. Also, gently shake crystals over flowers, covering completely. Seal container. Use a container that can be tightly sealed so that the desiccant does not absorb any moisture from the air rather than from the flowers. Most flowers dried in this manner are ready in about a week. Silica gel can be re-used simply by drying again the product in a warm oven. Leave for two days to one week, checking often to avoid overdrying (flowers will become brittle). Using Silica or Silica gel, we can improve the quality of flowers and it makes the flowers intact. Silica gel is the best preservative for keeping flowers in their natural form while they dry. It will take about 2 minutes to dry flowers in half a pound of silica gel on a setting of 200 - 300 watts. Drying with desiccants can produce some stunning results when it works. The process is however, a little unpredictable. Silica is the most popular desiccant used, although you can try borax mixtures too. Dry out the desiccant in an oven first and then prepare it in a shallow container which can be made airtight. Compact-headed flowers can be dried face up with their stem wired in position. Flowers that press well are California poppy, Chrysanthemum, Clematis, Columbine, Coneflower, Crocus, marigold, tulip, larkspur and Dahlia.

Sand Drying

With sand drying, the flowers are either laid in an inch bed of sand with space scooped out so that they rest snugly, or in the case of compact-headed blooms like zinnias, put them head first into the sand with wire supporting the stem. Cover only the petals and do not submerge the flower. Place the box in a well ventilated room with some gentle warmth. Plants that dry well with dessicant drying method are sunflowers, roses, yarrow, larkspur, peony, lavender, delphinium, statice, and anemone.

Sun Drying

Sun drying is the easy and cheap method. But during rainy days we can't dry flowers in this method. The flower bunches are hanged upside down in ropes or in bamboo splits No chemicals are used. Good aeration is must. Chances of fungal attack are very high in this method. Usually marigold, poppy, Zinnia, Chrysanthemum, Acroclinum, Globe amaranthus can be dried via this method.

Freeze Drying

It is an improved method over sun drying. Freeze drying equipments are costlier. But the quality of the dried flower is very high and fetches good price. Roses and pansy are dried through freeze drying.

Oven drying

Drying flowers in a warm oven uses much the same technique as drying them in a microwave.

To dry in an oven use a very low temperature (100 degrees or less) and dry for several hours. The oven must be fan assisted; otherwise too much moisture will be created. Marigolds, zinnias, cornflowers, lupins and chrysanthemums can be dried this way. Thick petal flowers like hyacinth and magnolias are unsuitable for microwave drying. While picking flowers for microwaves, use them just before they are fully open. Place the petals or flowers on an oven-proof tray, ensuring the petals do not overlap. Set the oven to the lowest setting and place the tray in the oven, leaving the door slightly ajar. Check the flowers regularly. Depending on the thickness of the flowers to be dried, the time of drying varies.

Press drying

This is an easy and popular way of drying flowers and is very useful for drying single specimens. Flower is kept in between the pages of a book or newspaper and is pressed with a weight. Pressing in books however is not the most practical method for large flowers or for many plants at a time. African violets, larkspur, pansies and ferns preserve well through this pressing technique. For this one may also use either blotting paper or ordinary papers. Other flowers-especially flat, so-called 'face flowers' like daisies, pansies, asters, cosmos and zinnias - can be dried by pressing them. Fern fronds can be dried this way as well. Simply placetheflowersbetweenseveralthicknessesofunglazedpaper,likeblotterpaper,newspaper, or an old phone book. Position the flowers so that none are overlapping or touching. Then place a heavy weight, such as stacks of bricks or books, evenly distributed, on top. Flowers dried in this manner are usually ready in two to four weeks, depending on their moisture content. There are also special devices called flower presses that do an excellent job of this. The flattened, dried flowers can then be arranged into a floral picture in a framed shadow box and hung on the wall or they can be 'stemmed' by using a piece of 20 gauge florist wire. Insert the wire up through the center of the dried flower from the back side. Bend the wire into a two-inch hairpin hook at the top and gently pull the hook back down through the flower's center until it just disappears. Then cover the wire with green or brown floral tape and they're ready to arrange.

Glycerin method:

Glycerin is filled after removing the moisture from the flowers. Very high quality products are obtained in this method. Prepare the foliage by stripping off the bottom leaves. Use the handle of a knife to crush the stems - this will facilitate absorption of the glycerine. Mix one part of glycerine with two parts of boiling water and pour the liquid into a vase or jar. Stand the stems in this mixture, ensuring they are covered with 10 cm of the liquid. Place in a cool, dark place. It will take the materials about 2–3 weeks to dry. By this time, the leaves would absorb the mixture and change slightly in colour. Check that the water and glycerine level remains constant, topping it up if necessary. Remove the materials from the solution, rinse them and dry with blotting paper. Glycerine-dried materials last for a long time and can be wiped with a damp cloth to keep them looking their best. Drying plant materials with glycerine keeps them more pliable and retains their natural shape, but it does tend to cause the foliage to change colour. Glycerine drying is recommended for leaves and berries. Leaves from the camellia flower or from the ivy, maidenhair fern or eucalyptus tree, are all good candidates for drying with glycerine.

Polyset polymer

By spraying polyset polymer flowers get dried. Drying time is very less in this method. It improves the color of the final product

B. Dyeing

“Procion” type colour is best for dry flowers.

Take 4 kg of dye-powder and mix with 20 litres of water. Dilute this solution in 800 litres of hot water.

Mix 2 litres of acetic acid

For very soft flowers add Magnesium Chloride to enhance the color. Soak the dried flowers until they absorb the colour.

C. Sulphuring

It is used to prevent enzymatic colour change.

Traditionally super granules have been burnt for about 2 hrs in a closed chamber along with dry flowers.

It is very toxic, so we have to check relevant safety instructions.

D. Bleaching

Bleached ornamental plant material provides a striking contrast when arranged with dried or dyed flowers.

Both oxidative (hypochlorite, chlorite, and peroxide) and reductive bleaching chemicals (sulphate and borohydride) are used for bleaching of ornamental plants and flowers.

Sodium chlorite is an excellent bleaching agent because it is relatively selective for lignin without damaging fiber.

Optimum pH of 3.5- 4.5 and temp 70° C is optimum for bleaching.

E. Post harvest handling of driedflowers:

Since dry flowers are made up of cellulose materials of plant origin, it invites a lot of insects.

Due to hygroscopic nature it allows to absorb moisture leading to problem of mould infection.

The dried flowers are treated with a suitable biocide (insecticide and fungicide) and are packed in water proof containers.

F. Packing

Card board boxes, thermo cool packing, poly lined or wax paper lined cartons are normally used for packing of dry flowers.



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